OLUME 48 NUMBER 2

TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY

An International Quarterly Journal

June, 1943

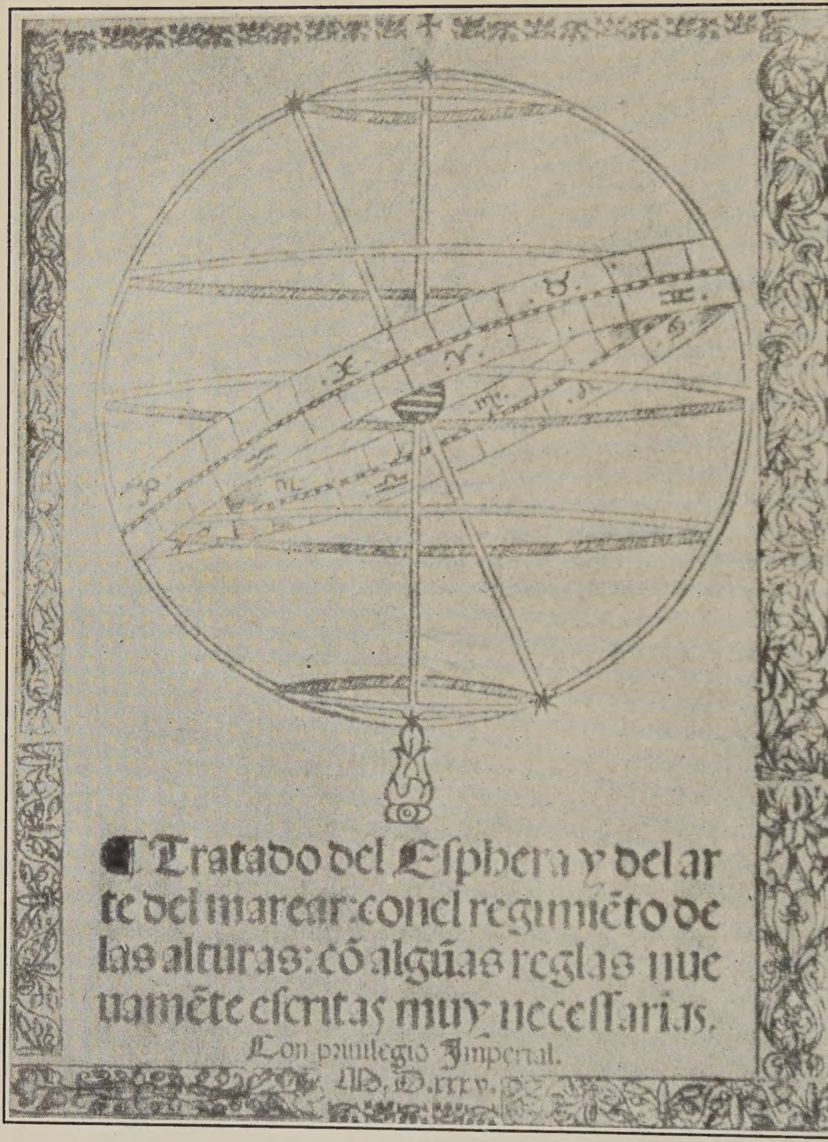
Founded by LOUIS A. BAUER
Conducted by J. A. FLEMING
With the Cooperation of Eminent Investigators

CONTENTS

(*Contents concluded over*)

PUBLISHED FOR
THE JOHNS HOPKINS PRESS, BALTIMORE 18, MARYLAND
THE RUTER PRESS, 420 PLUM ST., CINCINNATI 2, OHIO
THREE DOLLARS AND FIFTY CENTS A YEAR SINGLE NUMBERS, ONE DOLLAR

THE JOHNS HOPKINS PRESS
BALTIMORE 18, MARYLAND
Entered as second-class matter at the Post-office at Cincinnati, Ohio



Tratado del Esphera y del ar
te del marear: con el regimiẽto de
las alturas: cõ algũas reglas nue
uamẽte escritas muy necessarias.
Con priuilegio Imperial.
M.D.xxxv.

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME 48 JUNE, 1943 No. 2

ARCHAEOLOGICA GEOMAGNETICA—II

By SYDNEY CHAPMAN

The second of this series of translations or reproductions of old classic works on magnetism is, like the first*, a translation, by H. D. Harradon, of a work reproduced by G. Hellmann in his "Rara Magnetica."** This is Chapter VIII of Part II of Francisco Falero's treatise "Tratado del Esphera y del arte del marear," written in Spanish and printed in Seville in A. D. 1535 by Juan Cromberger.

Hellmann, who reproduced also the title-page of this book, refers to it as the first real treatise on navigation; and in his article on the beginnings of magnetic observation,† he states that though it was printed in 1535, after permission to publish had been granted in 1532, it appears to have been written much earlier, before 1519, when Magellan seems to have taken a copy of it with him on his journey round the world.

Falero's Chapter VIII, on the "Northeasting" of the compass-needle, is said by Hellmann to give the first printed detailed discussion of the magnetic declination, and the first printed description of methods for its determination. The existence of the declination seems to have gradually become recognized by a few scholars, instrument-makers, and navigators, as a general and world-wide phenomenon not due to imperfections in compass-needles or compass-observations, by about the middle of the fifteenth century, though there is no extant record to establish this; but most of the writers on magnetism and dials, even up to the end of the sixteenth century, made no mention whatever of the magnetic declination.§ This was due to the lack of any wide diffusion of the knowledge possessed by a select few; Falero's treatise must have helped to spread such knowledge, but no reference to his book is made, for example, by such writers as Rio Riaño (1589), William Borough

*Terr. Mag., **48**, 1-17 (1943).

A list of these and of other writings on magnetism reproduced by Hellmann in his "Neudrucke" is to be found in Terr. Mag., **3, 190 (1898).

†"Die Anfänge der magnetischen Beobachtungen," Zs. Ges. Erdkunde, Berlin, **32**, Heft 2 (1897). Also published separately [Berlin, W. H. Kühl, 27 pp. (1897)] in French translation in Bull. Soc. Belge Astron., **2** (1897), and in English translation by Mrs. L. A. Bauer in this JOURNAL, **4**, 73-86 (1899).

§Cf. Hellmann, "Anfänge"; A. Crichton Mitchell, Terr. Mag., **37**, 105-146 (1932); **42**, 241-280 (1937); **44**, 77-80 (1939), especially **42**, §27; also see "Geomagnetism," Chapman and Bartels, Chapter 26.

(1581), Simon Stevin (1599), Edmund Gunter (1622), and Henry Gellibrand (1635), who seem to have discovered independently some of the methods of observing the declination known to Spanish and Portuguese mariners 50 or 100 years before.

Further particulars of Falero and his contemporaries Guillen, Nunes, and de Castro, who contributed to the subject by the improvement of instruments and methods of observation, and by making and recording measurements of declination, are given by Hellmann in his "Anfänge," and may be read in English in Mrs. Bauer's translation in this JOURNAL and (less fully) in "Geomagnetism."

The improvements introduced by Guillen and Falero in the determination of the declination were concerned not with the magnetic aspect of the matter, but with the determination of the true north; originally this consisted, as is shown by the entry for September 13, 1492, in the diary of Columbus, simply in sighting from the compass to the Pole Star. Hellmann writes: "That in this way no great accuracy could be attained is self-evident. It is also to be questioned whether the movement of Polaris, which describes about the North Pole a circle of about 5° in diameter, was always taken into account. Already among the older writers on the magnet do we find an uncertainty in this regard; at one time they say that the magnetic needle points always towards the North Pole; at another, they assign to it the property of being ever directed toward the Pole Star."

Guillen improved the method by using an arrangement like a sundial, provided with a central style or gnomon, and taking observations of the shadow cast by the Sun at equal solar altitudes before and after noon. Falero describes this instrument and method (without mention of Guillen) and adds two other methods, by observation of the shadow at true noon, or at sunrise and sunset. Falero explains that to determine true noon, the duration of the night must be measured by an hour-glass or other precise method, and that true noon follows the sunrise at an interval equal to half the difference between 24 hours and the duration of the night. Such time-measurements may also, he explains, be used along with the observation of the solar altitudes to refine the accuracy of the first method (that of Guillen).

SOME EARLY CONTRIBUTIONS TO THE HISTORY OF GEOMAGNETISM—II AND III

By H. D. Harradon

(II) *Francisco Falero*—During the great age of discovery which followed the voyages of Columbus, Spain and Portugal took an important part in maritime enterprises and the exploration of lands beyond the sea. These ventures were responsible for the improvement of instruments and methods of navigation and the production of charts and maps. At that time it was widely believed that the determination of longitude at sea could be obtained from magnetic data, particularly from those of the declination, a belief which persisted throughout the seventeenth century and encouraged the making of many magnetic observations which, although useless as far as longitude-determinations were concerned, at least furnished data of great value in advancing knowledge of geomagnetism.

The first person who announced practical methods of determining the magnetic declination in printed form was Francisco Falero or Faleiro, a Portuguese in the service of the Spanish Navy, to whom we are indebted for the first real manual of navigation. This work entitled "Tratado del esphera y del arte del marear; con el regimiẽto de la altura; cõ algũas reglas nueuamẽte escritas muy necessarias," is extremely rare—so rare in fact that its existence has sometimes been doubted. The National Library in Madrid, however, possessed a copy and Hellmann was enabled to reproduce its title-page which we in turn present herewith in Plate 2. (A free translation of the title is as follows: "Treatise on the sphere and the art of navigation with manual of altitudes with some very necessary written rules. With imperial privilege. A. D. 1535.") The work was printed in gothic type and consists of 52 unnumbered folio pages. In the eighth chapter of the second part under the title "Del nordestear de las agujas," a translation of which we present (page 80), magnetic declination is discussed in detail for the first time in print and three methods are given for its determination, namely (1) by the azimuth-determination of the magnetic needle at true noon when the shadow of the pin falls to the north, (2) by observation of the shadow-azimuths at corresponding altitudes of the Sun before and after noon, (3) by observation of the azimuth at sunrise and sunset.[1] These methods are perhaps intended for an instrument (brújula de variación) devised by Filipe Guillen although no mention is made of it.

Filipe Guillen, an ingenious apothecary of Seville, who presented this instrument to the King of Portugal, João III, in 1525, has left nothing in writing concerning it. For its accurate description, we are indebted to the Spanish cosmographer and major pilot Alonzo de Santa Cruz, who took much interest in the efforts to determine the longitude from the variation of the compass.[2]

[1] G. Hellmann, Terr. Mag., **4**, 81-83 (1899).

[2] P. F. Mattelay ["Bibliographical History of Electricity and Magnetism," p. 70, London (1922)], points out that the magnetic charts devised by Alonzo de Santa Cruz, although based on very imperfect observations, antedated by more than 150 years the work of Edmond Halley.

(III) *Martin Cortes*—Although as early as 1537 Francisco Falero, in his "Manual of astronomy and nautical science" had taught the existence of the magnetic declination and given methods for its determination, Pedro de Medina raised all kinds of doubts against it in his "Arte de navigar." It was, therefore, a real service which Martin Cortes rendered in his "Breve Compendio de la sphera y de la arte de Navigar" (Seville, 1551) by devoting a detailed chapter to the magnetic needle and its variation which Hellmann reproduced in his "Rara Magnetica" because it contains the earliest exact description of the marine compass and its construction. As no copy of the first edition of Cortes' book (1551) was available, Hellmann was obliged to use the second edition (1556) for producing the facsimile which appeared in his "Neudrucke." The ideas regarding the magnetic pole which Martin Cortes expresses in Chapter 5, are much more obscure than those of Mercator, who has the priority in this matter, even if we suppose that Martin Cortes completed the manuscript of his book as early as 1545, as he states in the preface.

The title-page, reproduced on page 85, is from the second edition of "Breve compendio de la sphera etc." as published in "Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus" No. 10, by G. Hellmann. A free translation is as follows: "Brief compendium of the sphere and the art of navigation with new instruments and rules exemplified by many clever demonstrations; composed by Martin Cortes, a native of Bujalaroz in the Kingdom of Aragon and at present residing in the city of Cadiz; addressed to the most invincible Monarch Charles V, King of the Spains, our Master."

The writer wishes to express his obligation to Prof. A. Duperier of Imperial College of Science and Technology, London, for carefully examining these two translations and suggesting corrections for a number of obscure passages.

TREATISE ON THE SPHERE AND THE ART OF NAVIGATION

Francisco Falero

Part II, Chapter 8—*On the northeasting*[1] *of the needles*

The northeasting of the needles causes navigators many doubts, from which they may be freed by knowing precisely how much the needles northeast or northwest. In addition to this, other advantages will follow, such as knowing exactly in what direction they are sailing. Knowing this they will follow exactly their courses without error or wandering, and also it will help much to a knowledge of the longitude in which they are navigating.

The northeasting and northwesting of the needles are nothing else than their deviation from the meridian in which they are. They do not show this exactly except when they seek accurately the pole. And they seek this exactly, according to navigators, only when they are in the meridian of the islands of the Azores, and the most precise seek it in that of the Island of Corvo, according to the experience of some. Because, by reason of the differences of steels and of the lodestones, they do not all seek the pole in the same meridian, but some in a more eastern and

[1]That is, the declination of the compass-needle from the true north towards the east, and correspondingly for northwesting.

others in a more western one, although the difference is small. And likewise some decline to the northeast more than others, and others to the northwest. And in this as in all other particulars, which shall be stated below, all the needles may agree. For the magnitude of the error of all will be known in every place.

Accordingly you are to know that sailing from the meridian of the Island of Corvo or any other of the Azores in which the needle points exactly towards the pole, going toward the west the needles decline to the northwest, and sailing from the same meridian toward the east, they decline to the northeast. They are said to northeast because the amount by which they deviate from the pole is toward the northeast, and when they deviate from the pole toward the northwest, they are said to northwest. And the more the ships depart from the supposed meridian, the more the needles northeast or northwest, according to the direction in which they sail.

And it should be borne in mind also that on a ship departing from the said island along a parallel, over 90° of longitude the needles will continue to increase in their northeasting or northwesting and passing beyond 90° on the same parallel, by the same proportion which they had northwested, they will begin to be corrected, until they have sailed another 90°, which will be in the 180th degree of longitude from the said island. And they will be exactly in the antipodes, and the meridian exactly opposite to that in the same parallel, and the needles would again seek the pole exactly as they did in the island and meridian from which the voyage began, as proposed, pursuing their voyage by the same route until they returned to the same island from which they had first started, if this were possible (which it is not). In the same order and proportion they will again make their differences as in the first 180°, namely that up to the first 90°, the needles would continue to northeast and from that point onward they would begin to correct themselves so that when the ship had returned to the point and island from which it had first set out, they would again seek exactly the pole without northeasting or northwesting. And because the navigators following their courses on the zero-meridian of the north and south, find that the needles deviate from the pole, some of them hold an error, and it is that they think that, pursuing such a voyage, the needles northeast or northwest: It is said that although a ship sails on a meridian from one pole to the other never would the needles by which such a ship is governed northwest or northeast.

Since they find that they deviate from the pole, as in truth they do, and since such a deviation from the pole does not approach the northeast or the northwest, it cannot be said that it northeasts or northwests, nor is this deviation inconvenient, because the deviation which brings us into error is not that from the pole but from the meridian. And that this may be clear let the following be taken as an example: That if a ship were on the equator and the needle by which it was governed neither northeasted nor northwested, it is certain that it would seek the pole without indicating or seeking the northeast nor the northwest, nor our zenith, nor our antipodes, and this is because, it being true, it would not depart either towards the northeast or towards the northwest, and being on the equator it would not deviate toward our antipodes nor toward our zenith, because the point which the needle seeks is always

on the horizon on which the pole holds, by being on the equator as is stated. And inasmuch as this supposition is true, it must be remembered that the needle at no place or point on the sphere seeks exactly the pole except when it is on the equator for only there does it hold it on the horizon. And changing from the equator, by the amount the pole would be above or below the horizon the needle departs from it. So that if a ship with such a needle sailed from the equator on a meridian as far as 90°, if it were possible to place the pole in the zenith the needle would seek the pole in a point which would be separted from the pole itself 90°. Because the point which it would seek would be on the horizon of that which is below the pole; this would be the equator. But although the distance from the pole were 90°, not on this account would it depart from the meridian little or much, and not separating from it, it would decline neither to the northeast nor to the northwest; nor from such a deviation would there result error or harm because, as stated above, the deviation from the meridian is what places us in error and false beginnings and endings, and not that from the pole.

And in order that we may know how much the needles northeast or northwest, it is fitting to make an instrument in the manner and form of the figure which you will find in the present chapter, and which should be very round and flat, and so large that it may be divided into 360°, which are to be indicated with a rule, so that being taken from the center thereof, they will be indicated only on the circumference. And from the point at which you would wish that the needle point to the pole, you will begin to graduate on both sides beginning at one and ending in the line which you would indicate as the equator at 90°. And from the other pole toward the equator you would be able to graduate as many more, although it is not necessary. And after having graduated, indicate in the center with a compass a circle so large that the needle may be enclosed in it so that it may be fixed in the instrument. And you will make a half circle of iron or of steel or of some other substance which will be very round and flat and symmetrical, and will not be larger than the shadow it casts, and be drawn with the compass of the size of half the circumference of the instrument, and have sharp points greater than will fit the size of the half circle, so that the excess will drive into the instrument and keep it straight. And one point is to be placed at the point in which the needle indicates the north pole and the other where it points to the south pole.

And having thus made this instrument, if you should wish to make a determination with it at noon so that the half circle casts a direct shadow without any deviation, and if you are where the Sun is between you and the arctic pole, have the Sun enter on the side on which the needle points to the north pole. And if the Sun should be between you and the south pole, do the reverse. And if you thus desire to take the shadow, you have to move the instrument around to one side or the other without any regard to the needle until the half circle casts the shadow directly as said. And if, having thus taken the shadow, the needle should indicate the pole at the point at which the point of the circle should be, it would be true without northeasting because when the Sun arrives at each of the meridians, it casts a shadow or ray on those which below such a meridian are precisely at the pole, and for this reason every time that the needle agrees with the shadow or ray at noon you will have to con-

sider it true and all that the needle disagrees will be error. However, if the needle, the shadow being thus taken, should not indicate the pole on the point in which the point of the mid-circle should be, you will stretch a thread passing through the center of the needle and the point of the rose until it cuts the graduation. I say that the thread should pass over the point at which the needle indicates the pole very precisely and that you should count the degrees from the point of the circle to the point at which the thread cuts, and the (number of) degrees will be the amount which the needle northeasts according to the side on which it deviates, and for this much care must be taken in determining noon precisely, because all the error in determining it will appear in the count of this instrument. And we shall determine noon with an hour-glass or some other universal manner, etc., which is very precise and not one connected with the Sun, and counting with the sand the hours which are in the night and subtracting them from 24 which make up the natural day, those which remain will be those which there will be in the whole day from Sun to Sun in the region in which they were. Knowing how many there are at the beginning of the day, one has to count with the same glass noting the Sun and having counted, the mean or the half will be noon.

Also a good way to determine easily the meridian with the same instrument is to take the shadow of the Sun one hour, or two, or three, etc., before noon and to note on what part of the instrument it falls, and at similar times after noon as previously it was taken before (noon). Taking again the shadow, see to it that the Sun is at as great an altitude after noon as it was before when the first shadow was taken. Noting the two shadows, the mean of them will be the exact meridian. And this is a very good principle as being true, as also it may serve more times per day than the others and there may be no error in it, if the order of it is well observed.

You will also know with this instrument the meridian by determining how much the needle northeasts or northwests; placing in the center thereof a pin (shaft) and indicating the shadow on the instrument as the Sun rises and also as it sets, and the mean of the two shadows will necessarily be the meridian. And every time that the needle points to the pole in such a meridian which you have taken in the instrument, it will be true—it will neither northeast nor northwest. And if it does not point to the pole in such a meridian, you will count the degrees that there are from the meridian which you have taken and indicated between the two shadows, up to the point at which the needle points to the pole; and the degrees between them will be the amount which the needle will diverge from the meridian.

Also place the points of the half circle or two pins at the two ends or points of the line indicated on the instrument as the equinoctial, and at sunrise or sunset carefully adjust the instrument so that the circle or pins cast a shadow which goes in a straight line from one point of the circle to the other. Having done this you will draw a thread cutting the center and point of the needle and through the point at which the needle points to the pole to the graduation. And if the thread falls on the diametral line indicated on the instrument precisely—if the ship should be on the parallel on which the Sun should be that day—then the needle will be true. And if the thread should cut the gradua-

tion outside of the diametral line all the degrees from the line to the point where the thread cuts the graduation will be the amount by which the needle northeasts or northwests according to the side of the line or meridian from which it deviates. And this, as has been said, will be when the ship is on the parallel on which the Sun would be that day. And if the ship should be on another parallel, all the distance from the parallel of the ship to the parallel of the Sun must increase or decrease from the degrees which will be between the thread and the meridian of the instrument according to the side on which the thread and the needle depart from the meridian, and the remainder will be the amount which the needle will northeast, etc. And these are better ways of determining the meridian and the northeasting of the needles than by the higher altitude of the Sun taken with the quadrant, because the Sun at noon has so little more altitude than it has a little before and after noon that it is difficult to determine precisely the meridian; and more because this method serves us many times a day. And although there are other ways and rules for determining the meridian, no others are given here since they have not yet been tried and these suffice.

BRIEF COMPENDIUM ON THE SPHERE AND ART OF NAVIGATING

MARTIN CORTES

Chapter 3—*On the virtue and property of the lodestone*

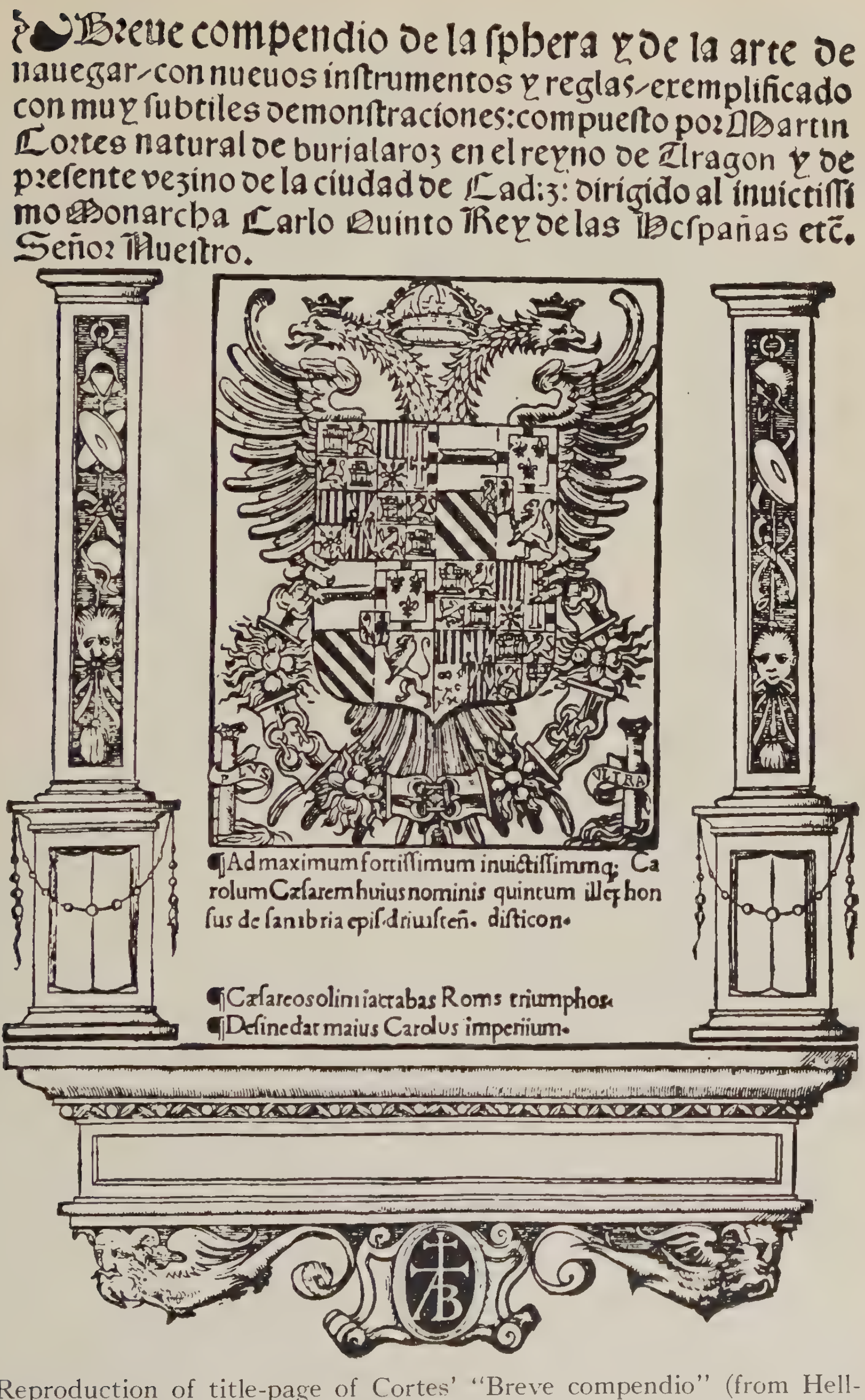
The lodestone according to the Cardinal Cusanus has essence, virtue, and operation. The virtue is engendered by the essence; from the essence and virtue is born the operation, so that the stone communicating its virtue to the iron for this reason causes the iron to move although between them there be a silver dish or plate or something similar. The attractive force of the lodestone causes the nature of the iron to join with it and at rest so much that although heavy and weighty it does not fall because the nature of the iron does not remain in it but joins with the nature of the stone which seems to extend whence we see that by this union it happens that it not only attracts this iron but this to another, and another to another and thus is formed a chain* as experience has shown. St. Augustine was surprised as he has written in the books of "De Civitate Dei"[1] because on a plate he saw a bit of iron agitated when the lodestone was moved about under the plate.

It is called a magnet after the name of its discoverer who (according

*Or string of beads.

[1]The passage referred to is Book 21, Chapter 4, of "De Civitate Dei." It is as follows: "When I first saw it (refers to the attraction of the magnet) I was thunderstruck (vehementer inhorrui), for I saw an iron ring attracted and suspended by the stone; and then, as if it had communicated its own property to the iron it attracted, and had made it a substance like itself, this ring was put near another and lifted it up, and as the first ring clung to the magnet, so did the second ring cling to the first. A third and fourth were similarly added, so that there hung from the stone a kind of chain of rings with their hoops connected, not interlinking, but attached together by their outer surface. Who would not be amazed by this virtue of the stone, subsisting, as it does, not only in itself, but transmitted through so many suspended rings and binding them together by invisible links?

"Yet far more astonishing is what I heard about the stone from my brother in the episcopate, Severus, bishop of Milevis. He told me that Bathanarius, once Count of Africa, when the bishop was dining with him, produced a magnet, and held it under a silver plate on which he placed a bit of iron; then as he moved his hand with the magnet underneath the plate, the iron upon the plate moved about accordingly. The intervening silver was not affected at all, but precisely as the magnet was moved backward and forward below it, no matter how quickly, so was the iron attracted above. I have related what I myself have witnessed. I have related what I was told by one whom I trust as I trust my own eyes."—Dod's translation, Edinburgh (1871).



Breue compendio de la ſphera y de la arte de nauegar/con nueuos inſtrumentos y reglas/exemplificado con muy ſubtiles demonſtraciones: compueſto por Martin Cortes natural de burjalaroz en el reyno de Aragon y de preſente vezino de la ciudad de Cadiz: dirigido al inuictiſſimo Monarcha Carlo Quinto Rey de las Heſpañas etc. Señor Nueſtro.

PLVS VLTRA

¶ Ad maximum fortiſſimum inuictiſſimumq; Carolum Cæſarem huius nominis quintum illefonſus de ſanabria epiſ. driuiſteñ. diſticon.

¶ Cæſareos olim iactabas Roma triumphos.
¶ Deſine dat maius Carolus imperium.

Reproduction of title-page of Cortes' "Breve compendio" (from Hellmann's "Neudrucke," No. 10)

to Pliny[2]) while tending his flock in eastern India wore hobnailed and iron-shod shoes (probably like the *esclopes* of Gascony or *çuecos* of Castille). His staff was pointed or tipped with iron and finding himself on a mass of this stone, he was unable either to move his feet or raise his crook or staff. For a time he did not know the reason but he gradually came to realize what up to that time he did not understand and recognized the property of the stone and the attractive virtue which it has. Its color does not differ from that of iron and for this reason it was called live (or quick) iron. The best lodestone is of sky-blue color, which color at times is taken on by the sea. There are five kinds or differences of the lodestone: The first Ethiopean; the second (from) Magnesia in Macedonia (to the right of the road to Lake Boebis); the third Echium of Boeotia; the fourth Troas near Alexandria; the fifth Magnesia in Asia. It is now found, however, in various other regions. It exists in Spain in many places. It is found in the Sierra Morena, near* the town of Calera which is of the order of Santiago in the Province of León; in a sierra of hilly ground of the Count of Vreña there is a large amount of it and also in other places. The most common stone and the one we use the most is from the Island of Elba of the Señor de Pomblín. That which I consider the best is from Denmark. This and the others have their own virtue of attracting iron. It is true that Theanxedes wrote that in Ethiopia there is another kind of magnet which separates from and repels iron. The commentator denies that the lodestone attracts iron to itself but says that the iron by natural inclination moves to the stone as to its natural place by reason of a property which the stone impresses on the iron. Besides this virtue and property which it has of thus attracting iron, it has another which gives to the iron virtue and power to indicate the two points of the horizon where the meridian cuts it which is in the two winds† north and south. This virtue is more intense in only two parts of the stone and these parts are always opposite, and thus they are contrary in their operation because if the iron is touched with one and placed where it can move freely it will point towards the north and if another iron is touched with the other part it will point towards the south. By making this experiment, it is known which part of the stone corresponds to the north, which the mariners call face (cara) of the stone, and which to the south. This stone is so necessary that without it, navigation would be defective and uncertain because it gives life to the needle and the needle guides the pilot in order that he may sail correctly by day and not go astray by night. It shows the way around the world, enables us to know the winds, and as the needle is so necessary let us show the order and way we should proceed to make one, because it would be possible on a voyage for the needle to be spoilt or get lost.

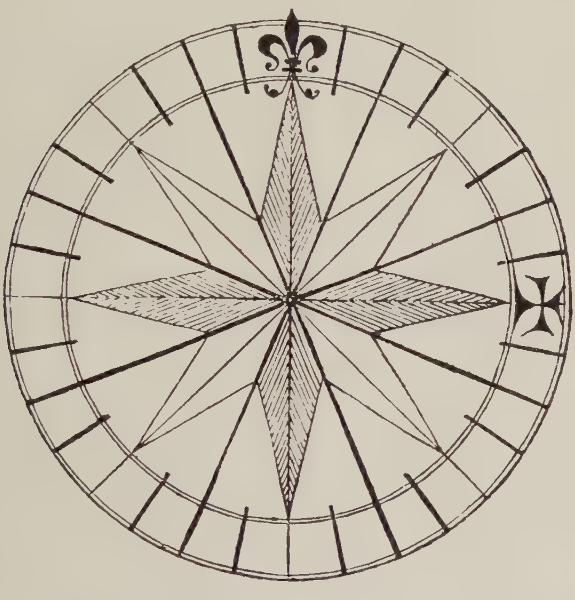
[2]The author doubtless has in mind the following passages: "It received its name *magnes*, Nicander informs us, from the person who was first to discover it, upon Ida (Isidorus says 'India'). It is found, too, in other countries, as in Spain, for example. Magnes, it is said, made this discovery, when, upon taking his herds to pasture, he found that the nails of his shoes and the iron ferrel of his staff adhered to the ground." Pliny, Natural History, xxxvi, Chap. 25 (Bostock and Riley's translation, London, 1857.)

*Or "and near," because the Sierra Morena is not in or near the Province of León.

†Here signifying "directions."

Chapter 4—*Of making the needle or navigating compass*

Take a piece of paper, like that used for playing-cards, and draw on it a circle of the size of a hand, more or less, on which are to be painted the 32 winds with the colors and in the order given in the first and second chapters on the winds and the chart, not forgetting to mark the north with a fleur-de-lys and the east with a cross and to embellish and adorn each of the others according to your fancy. Then on the lower part of this pasteboard a line is to be drawn directly under that of the north-south which shall be a mark for setting the irons or steels (needles). Afterwards, one is to take an iron or steel wire as thick as a large pin or corresponding to the size of the circle of the rose-paper, as a needle, or compass as it may now be called. This iron is now to be bent and



each of the parts should be 1-1/4 times as long as the diameter of the compass. The ends or points of these irons or steels are to be compressed and adjusted and in the middle so opened or closed until the ends come equal to the ends of the diameter of the compass and thus give to the steels an almost oval form [see Figure]. These irons are to be fastened to the lower part of the compass so that their ends or points come exactly in the north-south line, and in order to secure them thus they are to be covered with a thin pasted paper leaving the points or the ends of the iron uncovered. And these ends are to be touched with the lodestone as follows: The part which is below the fleur-de-lys is to be rubbed by that part of the stone which corresponds to the north (as is stated in the preceding chapter) and this is sufficient for perfecting the needle. But some desire for its over-perfection to touch the other end of the iron with that part of the stone which corresponds to the south.

It also was sufficient to touch with this part alone. In order that the demonstrative virtue be engendered, this touching of the iron with the stone is to be accomplished by striking some blows with a hammer on the part of the stone which is to be touched, namely, the north or the south. And some barbs (particles) will appear where the point of the iron is rubbed, as if it (the lodestone) were whetted, and some of these barbs of the stone will adhere to the iron. And having rubbed and attached the irons, one is to take a brass point of pyramidal form being broad at the base and rising to a point. This is made round or octagonal as seems best and at the base or wide part, a hole is to be bored with a bit and the hole should be pyramidal in form and penetrate to the middle of the pyramid or a little farther. This pyramid which the majority of mariners call "chapitel" should have a height of a finger's breadth or be according to the needle. And it has to be fitted into the center of the compass, the point extending from the upper part, and there it has to be attached and firmly fixed. Then one must take a round wooden box built around the needle so that it will not touch the walls of the box and as deep as the semi-diameter of the needle. The bottom of this box has to be false so that it may be taken off and put on in order that the steels may be again touched with the stone (which they call cevar [fattening]) when it may be necessary in order that the needle may not lose its virtue. In the middle of the bottom of this box is to be placed a pointed brass wire directed upwards and on this point the rose or compass has to go, the hole of the chapitel being seated on this point. And in order that no wind enter from above, this box must be covered with a glass. And thus magnetized by the stone and placed on the point it (the needle) will point towards the north and consequently indicate all the other winds. It is to be noted that after the needle has been touched in any of these ways, if they bring the north part of the stone to the north end of the needle, the north end will approach it and if they bring it to the south end of the needle, it will be repelled by it, and on the contrary if they bring the south part of the stone to the south end of the needle, it will approach it, and if to the north end, it will be repelled.* It is understood that the needle is so fixed as to have free movement. And also it is a good sign for knowing which is the north and which the south of the stone. Moreover this box is to be placed in another on two rings, one suspended within the other to assure that the needle may not rock even if the ship rocks. And this box has also to have its wooden cover in order that it may protect the other and to assure that the point of the pyramid or chapitel and its hole and the point on which it goes are upright, and also that the rose does not decline to either side. And if it should be more active than necessary the point on which it turns may be made blunter.

Chapter 5—*On the northeasting and northwesting of the needle*

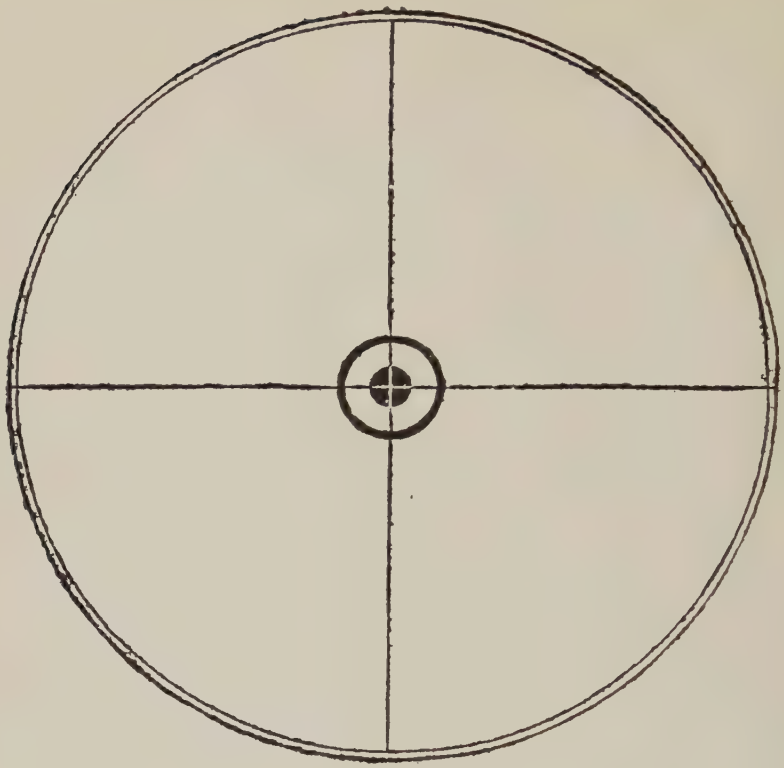
Many and various are the opinions which I have heard and read in some modern writers regarding the northeasting and northwesting of the needles and in my opinion none of them is exact and few of them hit the mark. They say that the needle northeasts when it declines

*There seems to be some confusion here with regard to the attraction and repulsion of unlike and like poles.

from the north to the northeast and that it northwests when it declines from the north towards the northwest. For the understanding of these differences by which the needles differ from the pole, it is necessary (being in the meridian where the needles point towards the pole) to imagine a point below the pole of the world—and this point should be outside of all the heavens contained beneath the *primum mobile.** This point or part of the heavens has an attractive virtue which thus attracts the iron touched with the part of the lodestone corresponding to that certain part of the heavens imagined outside of all the heavens moved by the *primum mobile*, because if in any of the heavens moved it is imagined that the attractive point moves to the movement of the *primum mobile*, then the needle in consequence will make the same movement in 24 hours. This is not found to be the case; therefore, this point is not in the mobile heavens nor in the pole because, if it were in it, the needle would neither decline to the northeast nor to the northwest. Hence, the cause of the northeasting or northwesting or deviating from the pole of the world is that, being in said meridian, the attractive point and the pole are in that same meridian and if the needle pointed directly to that point, it would point directly to the pole. And traveling from that same meridian towards the east (since the Earth is round) the pole of the world would continue to be on the left hand and the point of the attractive virtue would be on our right hand (which is towards the northeast wind) and the farther we proceed to the east, the greater will appear the distance until we arrive at 90° and at that point will be the greatest declining to the northeast. And as we advance farther beyond that point, it will appear to us that the attractive point approaches the meridian line and correspondingly the needle will compensate the northeasting until return to the same meridian is completed from the opposite direction from that in which we started and then the attractive point will be over the pole of the world and the needle will point directly to it. And passing on from there the pole of the world will remain on the right hand and the attractive point on the left and thus the needle will begin to decline to the northwest, increasing until it arrives from there to 90° and here will be the greatest declining to the northwest. Because returning toward the meridian of the attractive point, it will continue to correct itself until it reaches the meridian whence it started and there the needle will point to the pole of the world directly in line with the attractive point which is perpendicular under the pole. And if from there you again journey towards the west the pole would remain on the right hand and the attractive point on the left hand and hence the needle would decline to the northwest. This is the cause of the northeasting and northwesting of the needles. It is not to be understood that the northeasting and northwesting is uniform as one departs from the meridian where the needle points true. In the beginning, as one continues to go from the said meridian, there is a difference in quantity and the subsequent increase is small and the smaller the more one departs from the said meridian owing to the position† of circles intersecting on a sphere.

*In the Ptolemaic system of astronomy, the tenth and outermost of the concentric crystalline spheres which was supposed to rotate from east to west in 24 hours carrying the other spheres with it.

†The meaning of this passage is obscure. The text is as follows: "Por que es *passion* de circulos intersecantes en la sphera."



Thus the differences are like those of the declinations of the Sun which near the equinoxes are large and near the solstices small, all of which evidently appears in the following figure which is a circle which two diameters divide into four equal parts, intersecting in the center forming four right-angles. And from the central point (which is called a pole) emerges a movable meridian and in it goes a needle moving around the circle. The attractive point is somewhat separated from the pole of the world and from it extends a thread which always has to pass through the north-south of the needle. And the needle being in the meridian of the attractive point which passes through the pole, it will indicate the pole, and outside of it, it will decline to the northeast or northwest, departing from the true meridian which starts from the pole of the world.

It is the opinon of some mariners that the meridian (where the needles point to the pole) passes through the Island of Santa Maria and others through the Island of Corvo in the Azores.

Since the inconvenience is known I say that prudence will remedy it with time and one should not become negligent on a voyage always taking advantage of experience which will bring more profit than the subtle and delicate disputes about these natural secrets. In this manner the wise pilot has to know by experience how much a good needle (without the defect which some often have) declines to the northeast or northwest from one port to another. Thus he may know from a given

place to another that the needle will northeast or northwest so much (if it be half a quarter or a more or less amount as they depart from the said meridian where the needles point to the pole) and in navigation will give a guarantee that on such a voyage will northeast or northwest in the winds of the needle and will travel accurately in the winds which the chart indicates. Example, sailing from some island which is in the given meridian or from any other given place in search of a port which is truly northeast, if on this voyage the needle northeasts half a quarter, sailing by the winds of the needle northeast half a quarter towards the north, the course (saving other obstacles) would be towards the northeast which the chart indicates—and on this course account must be taken of this navigation and thus by the winds of the chart you will find the very port which you seek. By this order one should be governed in all navigation for which it is convenient that wise and experienced pilots take notes of sea-room, of northeasting and of northwesting which there is from port and port and having made a compilation of these notes to carry it as sailing-directions in the ships; and let them not correct the needles by sharpening the irons or steels on one side or the other of the point marked by the fleur-de-lys since that would cause much inconvenience. No less should graduations be admitted on the charts especially in order to know how much in each place the needle departs from the true meridian; an instrument can easily be made which will indicate it by day by the Sun and by night by the stars.

NOTES

(See also page 112)

12. *Repeat-stations in South America*—Joel B. Campbell and Fred Keller, Jr., magnetic observers of the United States Coast and Geodetic Survey, are continuing their observational work in South America, in cooperation with the American Republics. They will cover most of the Continent, going as far south as Punta Arenas, Chile, on the Strait of Magellan. At a number of stations near the magnetic equator, across the widest part of South America, they will observe the diurnal variations of declination and horizontal intensity. Their program also includes comparison of instruments at the Huancayo Magnetic Observatory in Peru, the Pilar Observatory in Argentina, and the Vassouras Observatory in Brazil. Because of unavoidable delays the observers are behind in their schedule. Consequently they may separate into two parties later, in order to complete their program this season. A second magnetometer-inductor loaned by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington has been sent to South America for use in case this is done.

13. *New Mexican volcano*—The new volcano which began erupting in the State of Michoacan, Mexico, on February 20, 1943, aroused much interest among scientists. At the invitation of the Mexican government and of scientists in that country, a United States Coast and Geodetic Survey party has gone to the vicinity of the volcano and will run magnetic traverses about its base. This project is part of the cooperative program with the American Republics. The party consists of Ralph R. Bodle and Nelson C. Steenland.

14. *Magnetic work of the United States Coast and Geodetic Survey*—Coast and Geodetic Survey parties making surveys of airports throughout the United States include magnetic declination observations at or near the airports as a regular part of the program.

Two magnetic parties of the Survey are in the field occupying repeat-stations for secular-change data now being collected for use in preparing magnetic charts of the United States for the epoch 1945. Nelson C. Steenland is in charge of one of the parties and Nathan O. Parker is in charge of the other. It is expected that during the season they will cover the territory east of the Rocky Mountains. Mr. Parker's equipment includes an earth-inductor loaned by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

New magnets have been installed in the horizontal-intensity variometers at the Tucson and San Juan Magnetic Observatories of the United States Coast and Geodetic Survey. In each case the recording-magnet and the temperature-compensating magnet are made from the same piece of Alnico (II) steel. The performance of the variometers has shown great improvement as a result of this change. In addition the variometer at San Juan was provided with a new suspension, the ends of which consist of quartz rods three mm in diameter. These ends are clamped firmly to the support and to the suspended mirror-frame by means of special four-jawed chucks made of duralumin.

AMERICAN MAGNETIC CHARACTER-FIGURE, C_A, THREE-HOUR-RANGE INDICES, K, AND MEAN K-INDICES, K_A, FOR JANUARY TO MARCH, 1943

By H. F. Johnston

Summaries of American *URSI* broadcasts have appeared regularly in this Journal since the issue for December, 1930.

As set forth in this Journal for June, 1937, "The Department of Terrestrial Magnetism and the United States Coast and Geodetic Survey with the cooperation of the United States Army and the United States

Table 1—*American magnetic character-figure C_A for Greenwich half- and full-days based on reports from Cheltenham, Honolulu, Huancayo, San Juan, Sitka, Tucson, and Watheroo for January to March, 1943*

Day	January			February			March		
	0^h-12^h	12^h-24^h	0^h-24^h	0^h-12^h	12^h-24^h	0^h-24^h	0^h-12^h	12^h-24^h	0^h-24^h
1	0.0	0.4	0.2	0.1	0.1	0.1	0.1	0.4	0.2
2	0.1	0.1	0.1	0.0	0.2	0.1	0.9	0.4	0.6
3	0.1	0.6	0.4	0.4	0.2	0.3	0.3	0.3	0.3
4	0.7	1.1	0.9	0.8	0.1	0.5	0.6	0.6	0.6
5	1.0	0.4	0.7	0.5	0.2	0.4	0.9	0.5	0.7
6	0.5	0.2	0.4	0.4	0.5	0.4	0.0	0.1	0.1
7	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
8	0.0	0.3	0.1	0.0	0.2	0.1	0.4	0.1	0.2
9	0.5	0.0	0.2	0.4	0.1	0.2	0.3	0.1	0.2
10	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0
11	0.0	0.2	0.1	0.7	0.1	0.4	0.0	0.9	0.5
12	0.5	0.1	0.3	0.0	0.0	0.0	0.6	0.7	0.7
13	0.0	0.0	0.0	0.9	0.4	0.6	0.0	0.0	0.0
14	0.0	0.0	0.0	0.1	0.0	0.1	0.4	0.1	0.2
15	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0
16	0.1	0.1	0.1	0.0	0.4	0.2	1.1	0.8	0.9
17	0.9	0.9	0.9	1.4	0.9	1.1	0.5	0.1	0.3
18	0.5	0.3	0.4	0.5	0.3	0.4	0.1	0.0	0.0
19	0.1	0.2	0.1	0.5	0.1	0.3	0.1	0.6	0.4
20	0.8	1.3	1.0	0.0	0.0	0.0	0.8	0.7	0.8
21	1.1	0.6	0.9	0.0	0.1	0.0	0.5	0.4	0.4
22	0.8	0.9	0.8	0.0	0.3	0.1	0.4	0.9	0.7
23	0.4	0.2	0.3	0.1	0.4	0.3	1.3	0.5	0.9
24	0.2	0.1	0.2	0.4	0.2	0.3	0.2	0.1	0.2
25	0.1	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.0
26	0.8	0.4	0.6	1.0	0.6	0.8	0.0	0.0	0.0
27	0.1	0.4	0.2	0.6	0.1	0.4	0.0	0.1	0.0
28	0.5	0.5	0.5	0.1	0.0	0.0	0.0	0.0	0.0
29	0.0	0.2	0.1				0.2	1.4	0.8
30	0.2	0.0	0.1				1.0	0.8	0.9
31	0.0	0.2	0.1				0.5	0.9	0.7
Means..	0.3	0.3	0.3	0.3	0.2	0.3	0.4	0.4	0.4

Table 2--Three-hour-range indices, K, January to March 1943

January 1943

	1	2	3	4	5	6	7	8
Si	0001 0112	1032 1321	0012 4322	2235 6542	4343 1332	2334 2221	1011 1110	0100 2211
Ch	0000 0213	1032 1210	1211 2223	2325 5442	5343 1233	4332 3212	2110 0100	0100 1223
Tu	0000 0232	2212 2221	1112 3233	3325 5533	4343 1233	3333 3222	1011 1101	0110 1222
SJ	0001 0233	2122 1220	1211 2313	2325 4532	4333 1322	3222 2211	1100 0100	0111 1111
Ho	1000 0221	1110 0221	1122 3223	2125 4332	2333 0122	2232 1111	0000 0210	1100 1222
Hu	0001 1332	2112 2221	0112 4433	2223 6543	4332 3433	3212 2322	0110 2200	0102 2331
Wa	2211 1233	2232 2322	2222 3323	3335 6553	4433 3433	2232 2333	2322 1222	2222 2323

	9	10	11	12	13	14	15	16
Si	2143 1111	0123 1012	1001 0201	1352 1111	1221 1111	1210 0000	0000 0100	0002 2321
Ch	3244 0100	1211 1123	1110 0111	2232 1001	2221 1111	0110 0110	0100 0111	0011 1112
Tu	2243 1221	1222 1114	1211 0212	2342 1013	2211 1112	1210 0010	0210 1213	1111 1223
SJ	2132 1210	1111 1212	0111 0221	2221 1121	1110 1110	0110 0100	0000 0200	0111 1112
Ho	2133 0111	2122 0012	1111 0112	1232 1010	1111 1111	0000 0000	0000 1012	2011 1202
Hu	2121 2321	1122 2323	1112 1332	2232 3222	1111 2221	0111 1220	0011 3311	1112 3332
Wa	2343 2122	2333 2223	2211 1322	2332 2223	2112 2211	1211 1111	1211 2212	2222 3432

	17	18	19	20	21	22	23	24
Si	3246 6432	2253 3131	0132 3231	1254 3654	4467 6423	5245 6442	3433 3121	2123 3211
Ch	3235 5432	2333 3121	2231 2221	2353 3454	6455 3223	5244 3443	4323 2122	4323 2122
Tu	3245 5433	2232 3231	2231 2323	2354 3645	5354 3324	5233 4543	3322 2112	4223 2223
SJ	3235 4432	2221 1011	1221 2122	2233 2655	5234 3124	5133 4333	3221 2211	3111 2222
Ho	3234 3223	2132 2121	1221 1112	2234 2454	3243 2213	4122 3222	1211 0121	2212 1111
Hu	3133 5543	2221 3321	1211 3333	1332 3544	3334 2113	3122 4433	3211 2332	2101 2332
Wa	3235 5543	3234 3332	2221 2433	2233 3555	4334 4324	4333 5543	3222 3222	2222 2332

	25	26	27	28	29	30	31
Si	1123 3100	2345 3311	1013 3221	0134 3231	1012 3121	2220 1111	1133 2321
Ch	2221 1110	3345 2312	2112 2211	0323 3222	1111 2121	4321 1001	2221 1122
Tu	2222 2111	3345 3332	2113 2321	1334 2232	2111 2123	3220 0012	2231 1222
SJ	1211 0211	2133 1211	2111 2211	1223 2222	1010 1111	3320 0011	1100 0011
Ho	1111 0011	2334 2211	2102 2221	1123 2211	1112 2121	2210 1001	1020 1212
Hu	1111 2220	2222 3432	1001 4331	1212 4331	1112 3331	3111 2211	1111 2332
Wa	2322 2212	3334 3422	2112 3322	2334 3433	2212 2222	2231 1112	2212 2323

February 1943

	1	2	3	4	5	6	7	8
Si	1121 1121	1231 2211	1333 3211	2345 3221	2244 4211	2033 4322	1232 0111	1112 2222
Ch	3121 0112	2211 1222	3323 2222	3344 2122	3232 2231	4132 2222	2310 0011	1111 1022
Tu	2021 1222	2121 1212	3332 3223	3344 2223	3333 3232	3122 2333	2320 1112	2111 1142
SJ	2021 0212	2111 1101	3322 1122	3233 2021	2231 1220	3122 1212	2210 0001	0010 1122
Ho	1010 1101	1021 1102	1222 3122	3334 1111	3223 3220	3122 1112	1100 0001	1012 1122
Hu	1020 2432	2110 3322	2322 3433	3222 3332	2211 3341	3111 3332	2221 2221	0110 2222
Wa	3222 2222	2221 3313	3233 3233	4324 3323	3223 3332	3223 2311	2211 1223	1221 2242

	9	10	11	12	13	14	15	16
Si	1133 2111	0010 2110	2253 2010	0202 1100	2244 3321	1333 1100	0122 1111	0010 0121
Ch	2122 2122	0111 1212	3332 1011	1202 1111	3343 3231	2222 1001	2123 1010	0100 0233
Tu	2333 1123	0111 1211	3452 2011	1202 1111	4343 3332	2223 1111	2123 1021	0110 0432
SJ	2222 1022	0000 1110	3342 0011	1102 0111	3332 2221	1111 0011	1121 1011	1000 0332
Ho	2222 0021	0000 0010	3432 2011	0102 0001	4332 2222	1121 0012	1113 1011	1011 0333
Hu	3221 3221	0011 2420	3332 2121	1200 1222	3331 5431	2211 2221	1122 2231	1001 2343
Wa	3232 1121	1111 2221	3442 3121	1111 2122	3342 3221	3223 1112	2122 1121	1211 1332

	17	18	19	20	21	22	23	24
Si	2478 6433	2243 3112	3143 2310	0203 3100	0032 0110	0002 2112	1123 2232	2333 3121
Ch	3456 3332	3342 2123	4222 2211	0303 2111	0021 1110	0002 1122	1123 2233	2422 1122
Tu	4557 4334	4342 2112	4233 2311	0303 2212	0021 1101	1012 2123	1233 2232	2423 2222
SJ	4446 4223	2232 2111	3122 2200	0202 1011	0010 0100	0002 1112	0122 1232	2312 1121
Ho	4546 3221	2232 1102	2122 2201	1102 1111	0010 0111	1012 2112	1222 1222	1112 1102
Hu	3334 5553	3222 3322	3122 4532	0201 3311	0001 2322	0011 3332	1122 3442	2312 3432
Wa	3446 5333	2233 4212	2133 3212	2112 2311	1111 1212	1123 3123	2223 3222	3223 3222

	25	26	27	28
Si	0213 3332	4546 2432	3524 3111	2223 1011
Ch	0201 1244	6423 2333	5413 1121	1212 1110
Tu	1202 1344	4534 1443	4423 2132	1222 0020
SJ	0200 0334	4423 2332	4322 1111	1100 0000
Ho	0202 1234	3324 1231	1313 1011	1111 1000
Hu	0201 2344	3322 2433	3211 3331	2100 0111
Wa	3112 2554	4333 1452	2213 2122	2121 1111

" Interpolated.

Table 2--Three-hour-range indices, K, January to March 1943--concluded

March 1943

	1	2	3	4	5	6	7	8
Si	0100 3311	1155 5211	1124 4122	1355 5223	3342 2331	2130 2231	2121 1211	2243 3122
Ch	0201 2321	2444 2121	0123 2122	3334 3134	3433 2323	3121 1121	2111 1123	3422 2112
Tu	1312 2332	2353 3122	0124 3233	2343 3223	3442 3422	2131 1132	2121 2223	4332 3213
SJ	0202 2121	2334 1012	0133 2122	2234 2223	2432 2322	2010 1121	2101 1111	3311 0112
Ho	0211 2221	2163 4112	1123 1122	2232 3222	2222 2201	1021 0111	2100 1111	1223 2001
Hu	1202 3431	2233 4322	1123 3222	2223 3433	2332 4431	2110 3332	2101 2322	3312 2222
Wa	1311 3321	2244 4222	1223 3223	3344 5334	3342 2532	2121 3232	1111 2221	2112 3322

	9	10	11	12	13	14	15	16
Si	2132 2211	1022 1210	1213 3242	3313 4521	1100 1111	1234 1311	1001 1211	2247 4233
Ch	4122 1122	2101 1112	4211 2254	4522 3332	2100 2011	3422 2311	1101 0111	2456 3345
Tu	3123 2222	2011 1122	3212 2353	3423 5432	2111 1121	3333 2321	1111 1222	3445 3344
SJ	3022 1110	1001 1001	3100 1253	3323 3321	2000 2011	2222 1101	1001 0101	2345 3243
Ho	1123 2111	1001 1101	2001 2253	2322 3321	1100 1011	1223 1111	1001 0211	2324 3133
Hu	3123 3321	1013 2321	2112 3453	3313 4431	1001 4211	1211 3311	1001 1311	2334 4442
Wa	2123 3322	1111 1222	1111 2453	3323 3532	2111 2112	2323 2311	1111 1211	3336 4332

	17	18	19	20	21	22	23	24
Si	2125 4111	1133 2221	1032 1233	2366 4341	1335 4221	2214 3344	5664 4232	1143 4311
Ch	5113 3012	1222 0111	1032 2343	3444 3352	2334 2222	2223 3345	6554 2233	2231 2311
Tu	4123 3112	1232 1212	2132 2344	2444 3342	2334 2232	2324 2344	5553 2232	1232 3310
SJ	4113 2012	1122 1211	1022 1333	2233 3342	1233 2122	2223 3244	5442 2232	1131 2210
Ho	3113 2011	1122 1111	0022 1233	2243 3331	1124 2112	2213 2232	3443 2121	1122 3200
Hu	3113 3211	1121 2331	1121 2443	2223 4431	2222 1332	2212 4444	5332 3333	1121 2310
Wa	3122 3211	1112 1211	1122 2333	3355 3341	2124 2322	2223 3444	3434 4332	2232 3311

	25	26	27	28	29	30	31
Si	0311 0110	1230 0211	1002 1221	0012 2121	2322 3355	4446 4433	3322 3323
Ch	2311 1111	2221 1112	1100 0131	0010 1031	3322 3467	6534 3344	5321 2335
Tu	0311 1011	2230 0111	2011 1222	0011 1121	2323 3475	4444 3343	4421 2334
SJ	0310 0000	2220 0101	1000 0121	0000 0121	3222 2274	5223 3233	4311 1234
Ho	1100 0000	1010 1101	2011 0121	0010 0021	1122 3364	2333 2132	2220 2324
Hu	0212 2210	2211 2221	1011 2322	0011 2231	2222 3564	4222 4333	4311 3444
Wa	1111 1111	2111 1211	2111 2211	1111 1121	1113 4465	3334 4344	2221 3534

Table 3--Weighted average of reduced three-hour-range indices, January to March 1943

Day	January 1943 Values K_A	Sum	February 1943 Values K_A	Sum	March 1943 Values K_A	Sum
1	0x 0x 0 0x 0 2 2 2x	8	2x 1 2 1 1 2 1x 2	13	0x 2x 0x 1x 2x 3 2 1	13x
2	2 1 2x 2 1x 2x 2 1	14x	2 2 2 1 1x 2 1 2	13x	2 2x 4 3x 3 1x 1x 1x	19x
3	1 1x 1x 1x 2x 2x 2 3	15x	3 3 2x 2x 2 2 2 2x	19x	1 1x 2x 3 2x 1x 2 2x	16x
4	3 3 2x 5 5 4 4 2x	29	3x 3 3x 4 2 2 2 2	22	2x 2x 3x 3x 3x 2x 2x 3x	24
5	4x 3x 3x 3 1x 2x 3 3	24x	3 2x 2x 2x 2x 2x 2x 1x	19x	3 3x 3x 2 2x 3x 2 2	22
6	3 2x 2x 2x 2 2 2 2	18x	3x 1 2x 2 2 2x 2 2	17x	2 1 2 0x 2 1x 2x 1x	13
7	1x 1 1 0x 0x 1x 1 0x	7x	2 2x 1x 0x 0x 1 1 2	11	2 1 1 1 1x 2 1x 2	12
8	0x 1x 0x 1 1x 2 2 2x	11x	1 1x 1x 1 1x 1x 2x 2	12x	2x 2x 2 2 2x 1x 1 2	16
9	2x 2 3x 3 1 1x 1 1	15x	2x 2 2x 2 1x 1 2 1x	15	2x 1 2x 2x 2 2 1x 1x	15x
10	1x 2 2 2 1 1 1x 3	14	0 0x 1 0x 1x 2 1x 0x	7x	1x 0x 1 1x 1x 1x 1 1	9x
11	1x 1x 1 1 0 2 1 1x	9x	3x 3x 4 2 1x 0 1x 1	17	2x 1x 1 1x 2x 3 5 3	20
12	2 3 3x 2 1x 1 1 2	16	1 2 0 1x 1 1 1 1	8x	3 3x 2 2x 3x 4 2x 1x	22x
13	2 2 1x 1 1x 1x 1 1	11x	3x 3 4 2x 2x 2x 2x 1x	22	1x 1 0x 0x 2 0x 1 1	8
14	0x 1x 1 0x 0 0x 0x 0	4x	2 2 2 2 1 0x 0x 1	11	2 3 2 2x 2 3 1 1	16x
15	0 1 0x 0x 1 1x 0x 1	6	1x 1x 2 2x 1 0x 1x 1	11x	1 0x 0x 1 0x 2 1 1	7x
16	1 1 1 1x 1x 2x 2 2	12x	0x 1 0x 0x 0x 2x 3 2x	11	2x 3 3x 5x 3x 3 3x 3x	28
17	3x 2x 3x 5 4x 4 3 2x	28x	3x 4x 5 6x 4 3 3 3	32x	3x 1 1x 3 3 1 1 1x	15x
18	2x 2x 3 2x 2x 1x 2x 1x	18x	3 2x 3x 2x 2x 1x 1 2	18x	1 1x 2 2 1 2 1x 1	12
19	1x 2x 2x 1 2 2x 2x 2x	17	3x 1x 3 2x 2 2x 1 1	17	1 0x 2x 2 2 3 3x 3x	18
20	2 2x 4 3x 2x 5 5 4x	29	0x 2 0 2x 2 1x 0x 1	10	2x 3 4 4 3x 3x 4 1x	26
21	5 3x 4x 5 3 2x 2 3x	29	0 0 1x 1 0x 1x 1 1	6x	1x 2 2x 4 2x 2 2 2	18x
22	4x 2 3x 3 4 4 3x 3	27x	0x 0 1 2 2 1x 1x 2x	11	2 2x 1x 3 3 3x 4 4	23x
23	3x 3 2 2 2 1x 2 2	18	1x 2 2x 2x 2 2x 3 2x	18x	4x 4x 4 3x 3 2x 3 2	27
24	3 2 1x 2 2 2 2 2	16x	2x 3 2 2x 2 2 2 2	18	1x 1x 3 2 3 3 0x 0x	15
25	2 2x 2 1x 1x 1x 1 0x	12x	1 2 0x 1x 1x 3 4 4	17x	0x 2x 1 1 0x 1 0x 0x	7x
26	3 3 3x 4x 2 3 1x 2	22x	4x 4 3 3x 1x 3 3x 2x	25x	1x 2 2 0x 0x 1x 0x 1	9x
27	2 1 1 2 2 2x 2 1x	14	3x 3x 1x 3 2 1 2 1x	18	1x 0x 0x 1 1 2 2 1	9x
28	1 2x 2x 3x 2x 2x 2x 2	19	2 1x 1x 1x 1 0x 1 0x	9x	0 0 1 1 1 1 2 1	7
29	1x 1 1 1x 2 1x 2 1x	12			2 2 2 2x 3 4 6 5x	27
30	3 2x 2 0x 1 0x 0x 1x	11x			4 3x 3 3x 3x 3 3x 3x	27x
31	2 2 2 1 1x 2 2 2	14x			3x 3 2 1 2x 3x 2x 4	22

Navy communication-services and several amateur radio stations have undertaken to supply the American character-figure based upon the reports of the seven American-operated observatories—those of the Department of Terrestrial Magnetism at Huancayo in Peru and at Watheroo in Western Australia, and those of the United States Coast and Geodetic Survey at Cheltenham (Maryland), Honolulu (Hawaii), San Juan (Puerto Rico), Sitka (Alaska), and Tucson (Arizona)." This character-figure is being designated C_A, and its values for the first twelve, the second twelve, and all twenty-four hours of each Greenwich day for January to March, 1943, are given in Table 1.

The three-hour-range indices, K, have been compiled since April 6, 1940, for each of the seven American-operated observatories. The eight indices for each day give geomagnetic activity for three-hour periods successively during the Greenwich day. The indices range from "zero" very quiet to "nine" extremely disturbed. The K-indices for Sitka (Si), Cheltenham (Ch), Tucson (Tu), San Juan (SJ), Honolulu (Ho), Huancayo (Hu), and Watheroo (Wa), for January to March, 1943, are given in Table 2. Interpolated indices are shown thus, $\ddot{3}$.

In the manner set forth in the JOURNAL for September, 1940, the indices are standardized into reduced indices K_r to eliminate local variations. A weighted mean index K_A, is derived from the reduced indices. The reduced indices from Si, Ch, and Wa are given double weight and those from Tu, SJ, Ho, and Hu are given single weight. The weighted indices, K_A, for January to March, 1943, are given in Table 3. A superior cross ($^{\times}$) following an index-number denotes a half-unit, thus $5^{\times} = 5.5$, etc.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C., May 20, 1943

LIST OF GEOMAGNETIC OBSERVATORIES AND THESAURUS OF VALUES

By J. A. Fleming and W. E. Scott

The International Association of Terrestrial Magnetism and Electricity at the Stockholm Assembly in August 1930 appointed a Committee to consider existing and desirable distribution of magnetic and electric observatories and the better coordination of work and publications of existing observatories. That Committee submitted reports at subsequent assemblies of the Association in 1933 (Lisbon), 1936 (Edinburgh), and 1939 (Washington) which are published in Bulletins 9, 10, and 11 of the Association. At the Lisbon Assembly[1] it recommended that there be prepared and published a second and revised edition of the "Liste des observatoires magnétiques" of 1910[2] to include not only detailed information regarding organization, history, geographic position, elevation above sea-level, instrumentation, publications, personnel, and special remarks for each observatory, but also a complete thesaurus of annual values of the geomagnetic elements. An up-to-date summary of finally corrected annual values for both existing and discontinued observatories is much needed for international services, unification of publications, and centralization of magnetic data. This need has been partly met by tabulations of annual values published from time to time in the "Transactions" of the triennial meetings of the Association and in this Journal. There is, however, so great diversification of published material in the past, both for various observatories and for the same observatory, that it is difficult to select homogeneous material for purposes of research.

The Committee repeated its recommendation and submitted a resolution at the Edinburgh Assembly in September 1936.[3] That resolution was adopted in the following form:

> (1) *List of observatories and thesaurus*—The Association regards as desirable the publication of a complete list of all fixed magnetic and electric observatories, both now and formerly operating, with brief statements of geographical coordinates, elevations, instrumental equipment, data published regularly, data available upon special request, and special remarks covering operation and investigations, and authorizes its Executive Committee to allot such funds as may be necessary to compile and publish such a list.
>
> It is also recommended that a thesaurus of magnetic values should be prepared and published at the cost of the Association.

A somewhat similar resolution, submitted by J. A. Fleming, was also adopted at the Warsaw Meeting of the Commission of Terrestrial

[1]Trans. Lisbon Assembly, September 1933; Internat. Union Geod. Geophys., Ass. Terr. Mag. Electr., Bull. No. 9, 107-113 (1934), Copenhagen.

[2]E. Merlin and O. Somville, Liste des observatoires magnétiques et des observatoires séismologiques Bruxelles, Observatoire Royal de Belgique, x+192 pp. (1910).

[3]Trans. Edinburgh Meeting, September 1936; Internat. Union Geod. Geophys., Ass. Terr. Mag. Electr., Bull. No. 10, 164-174 (1937), Copenhagen.

Magnetism and Atmospheric Electricity of the International Meteorological Organization in September 1935. This resolution was as follows:[4]

(IX) The Commission regards as desirable the publication of a revised edition of the "Liste des Observatoires magnétiques et des Observatoires séismologiques," by Merlin and Somville, published in 1910, giving a complete list of all magnetic and electric observatories, both operating and non-operating, with brief statements of geographical coordinates, elevations, instrumental equipment, data published regularly, data available upon special request, and special remarks covering operation and investigations.

The Executive Committee of the Association of Terrestrial Magnetism and Electricity made a small allotment to begin the work in 1936. J. A. Fleming of the Association was instructed to undertake the gathering and preparation of the material in collaboration with A. Nippoldt who was designated by the Commission of Terrestrial Magnetism and Atmospheric Electricity. Unfortunately the untimely death of Nippoldt in 1936 and the urgency of other duties have delayed the preparation and distribution of questionnaires to the directors of geomagnetic and electric observatories and the outbreak of the second world war has greatly restricted necessary mail communication. Despite these difficulties the compilation of annual values has been maintained. Because of the uncertainty as to post-war conditions and the pressure of post-war rehabilitation it has been decided to publish several sections of the revised "List" in a preliminary form. These will include one table giving geographic position and annual values and a second table summarizing geomagnetic coordinates and other required computational factors for existing and discontinued observatories. These will be arranged according to geographic latitude which will necessitate a third alphabetical listing for ready reference. Other sections contemplated include results for various magnetic-activity measures, historical accounts with descriptions of equipment and methods, and addresses of personnel and of investigators interested in the use of geomagnetic data.

Table 1, of which the first portion is published herewith, will be continued in succeeding numbers of the JOURNAL. Every effort has been made to consult the most recent publications and corrections from all available sources; in this the extensive file of archives and library of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, has been most helpful. For some observatories the published results give apparent evidence of lack of accuracy either in the observational or the computational work. Fortunately the number of such cases is small. The procedure for the publications of the different observatories is quite varied and it has been necessary frequently to compute the various components. Usually the published results are for declination (D), horizontal intensity (H), and inclination (I) or vertical intensity (Z), but frequently check computations through the equations relating the various elements and components show lack of consistency or harmony and resulting confusion, to say the least. Another disturbing factor has been typographical errors, many of which fortunately were disclosed upon inspection of means or adjacent values.

To compute and check the components seven-place logarithmic

[4]Procès-Verbaux, Commission de Magnétisme Terrestre et d'Electricité Atmosphérique, Réunion de Varsovie, 1-5 Septembre 1935, Organisation Météorologique Internationale, No. 30, 94 pp., Leyde (1936); see also abstract by V. Laursen, Terr. Mag., **40**, 407-411 (1935).

TABLE 1—*Annual values of geomagnetic elements at observatories*

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Baie Tichaja (Calm Bay)..........	+80 20	52 48	1933	+21 10.9	+83 06.7	6598	6150	+2384	+54611	55008
			1934	+21 27.8	+83 08.0	6567	6111	+2403	+54534	54921
			1935	+21 44.6	+83 10.7	6529	6064	+2418	+54578	54967
			1936	+21 58.3	+83 12.7	6500	6028	+2432	+54614	54998
Chelyuskin............	+77 43	104 17	1935	+25 32.1	+86 00.4	4024	3631	+1734	+57649	57784
			1936	+25 20.9	+86 02.5	3984	3600	+1705	+57585	57710
Dickson...............	+73 30	80 24	1933	+28 31.6	+83 05.0	6971	6125	+3329	+57430	57852
			1934	+28 29.4	+83 06.8	6909	6072	+3296	+57208	57619
			1935	+28 37.5	+83 09.9	6816	5982	+3265	+56854	57265
			1936	+28 41.4	+83 11.7	6783	5950	+3256	+56833	57240
Matochkin Shar........	+73 16	56 24	1923[a]	+20 30.6	+80 02.8	9517	8914	+3334	+54232	55061
			1924	+20 37.5	+80 05.4	9491	8883	+3343	+54326	55149
			1928	+20 59.1	+80 18.3	9295	8679	+3229	+54405	55192
			1929	+21 05.2	+80 18.8	9265	8645	+3333	+54284	55068
			1933	+21 41.3	+80 29.6	9078	8435	+3354	+54219	54974
			1934	+21 49.3	+80 31.6	9046	8398	+3363	+54214	54964
Tromsö...............	+69 40	18 57	1930	− 4 07.7	.. ....	11567	11537	− 833	.....	.....
			1931	− 3 59.6	+77 02.6	11548	11519	− 804	+50198	51509
			1932	− 3 49.0	+77 05.8	11499	11473	− 765	+50195	51495
			1933	− 3 37.3	+77 07.7	11472	11449	− 725	+50203	51497
			1934	− 3 25.9	+77 10.0	11441	11421	− 685	+50223	51510
			1935	− 3 14.3	+77 12.6	11407	11389	− 644	+50246	51525
			1936	− 3 04.8	+77 14.8	11379	11363	− 611	+50276	51548
			1937	− 2 53.7	+77 17.2	11350	11336	− 574	+50308	51573
			1938	− 2 44.1	+77 17.8	11325	11312	− 540	+50240	51501
Petsamo...............	+69 32	31 15	1933[b]	+ 5 46.2	.. ....	11341	11284	+1140	+50838	52088
Godhavn..............	+69 14	306 29	1927	−58 28.4	+81 34.7	8259	4319	−7040	+55788	56396
			1932	−57 07.3	+81 34.1	8218	4461	−6902	+55442	56048
			1933	−56 48.2	+81 33.6	8219	4442	−6915	+55389	55995
			1934	−56 30.4	+81 33.7	8209	4530	−6846	+55330	55936
			1935	−56 13.8	+81 34.2	8193	4554	−6811	+55284	55889
			1936	−55 57.4	+81 34.2	8187	4583	−6784	+55237	55840
			1937	−55 40.8	+81 33.9	8183	4614	−6758	+55184	55787
Sodankylä.............	+67 22	26 39	1914	+ 0 18.3	+75 19.2	12905	12905	+ 69	+49260	50923
			1915	+ 0 27.2	+75 22.1	12853	12853	+ 102	+49232	50882
			1916	+ 0 34.6	+75 25.0	12806	12805	+ 129	+49224	50862
			1917	+ 0 42.0	+75 27.6	12765	12764	+ 156	+49219	50847
			1918[c]	+ 0 49.2	+75 30.7	12717	12716	+ 182	+49216	50832
			1919	+ 0 55.9	+75 33.5	12676	12674	+ 206	+49224	50830
			1920	+ 1 04.1	+75 35.8	12639	12637	+ 236	+49211	50808
			1921	+ 1 13.3	+75 37.6	12605	12602	+ 269	+49189	50778
			1922	+ 1 22.4	+75 40.5	12560	12556	+ 301	+49186	50764
			1923	+ 1 30.6	+75 42.6	12529	12525	+ 330	+49189	50760
			1924	+ 1 41.2	+75 45.4	12490	12484	+ 368	+49204	50765
			1925	+ 1 53.3	+75 48.4	12440	12433	+ 410	+49184	50733
			1926	+ 2 01.0	+75 52.0	12392	12384	+ 454	+49210	50746
			1927	+ 2 10.6	+75 54.7	12357	12348	+ 469	+49238	50765
			1928	+ 2 18.9	+75 57.2	12317	12307	+ 497	+49228	50746
			1929	+ 2 27.2	+76 00.0	12270	12259	+ 526	+49212	50719
			1930	+ 2 36.5	+76 04.0	12207	12194	+ 556	+49202	50693
			1931	+ 2 45.1	+76 06.0	12182	12168	+ 585	+49223	50708
			1932	+ 2 55.4	+76 08.9	12145	12129	+ 619	+49251	50729
			1933	+ 3 03.9	+76 11.7	12110	12092	+ 648	+49278	50751
			1934	+ 3 13.7	+76 13.9	12083	12064	+ 681	+49310	50770
			1935	+ 3 23.8	+76 17.2	12042	12020	+ 713	+49347	50795
			1936	+ 3 32.1	+76 19.1	12020	11997	+ 741	+49377	50819
			1937	+ 3 41.5	+76 23.1	11979	11954	+ 771	+49459	50889
Ouellen...............	+66 10	190 09	1935	+16 03.2	+75 40.8	13672	13139	+3781	+53559	55274
			1936	+15 57.4	+75 40.5	13677	13150	+3760	+53564	55282
College...............	+64 52	212 11	1933	+30 25.6	+77 14.6	12572	10841	+6367	+55530	56935
			1942.0	(+29 52.9)	(+77 11.9)	(12576)	(10904)	(+6265)	(+55347)	(56758)
Dombås...............	+62 05	9 06	1934	(− 8 16)	(+73 31.9)	(14040)	(13894)	(−2019)	(+47495)	(49526)
			1935	(− 8 07)	(+73 34.6)	(14000)	(13860)	(−1977)	(+47496)	(49517)
			1936	(− 7 58)	(+73 36.3)	(13970)	(13835)	(−1936)	(+47481)	(49494)

[a]For 3 months, October to December. [b]Polar-year, August 1932 through August 1933.
[c]No observations March, April, and May, 1918.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Lerwick	+60 08	358 49	[1]1923	−15 44.5	+72 33.6	14655	14105	−3976	+46650	48898
			[1]1924	−15 30.6	+72 35.7	14642	14109	−3915	+46708	48950
			[1]1925	−15 17.7	+72 37.2	14621	14103	−3857	+46712	48947
			1926	−15 02.8	+72 37.1	14618	14117	−3795	+46699	48933
			1927	−14 49.9	+72 38.1	14607	14120	−3739	+46713	48944
			1928	−14 37.1	+72 39.4	14585	14113	−3681	+46702	48926
			1929	−14 23.6	+72 40.3	14556	14100	−3618	+46651	48869
			1930	−14 11.2	+72 41.6	14528	14084	−3561	+46625	48835
			1931	−13 59.6	+72 42.3	14517	14086	−3510	+46623	48830
			1932	−13 46.1	+72 43.5	14495	14078	−3450	+46608	48809
			1933	−13 34.0	+72 44.6	14477	14073	−3396	+46605	48802
			1934[d]	−13 21.9	+72 48.4	14463	14071	−3343	+46744	48930
			1935	−13 09.5	+72 49.9	14446	14067	−3289	+46758	48939
			1936	−12 57.8	+72 51.7	14429	14061	−3236	+46791	48965
			1937	−12 46.6	+72 53.3	14412	14055	−3187	+46812	48980
Sloutzk (Pavlovsk)	+59 41	30 29	1900	+ 0 37.6	+70 37.4	16548	16547	+ 181	+47050	49877
			1901	+ 0 41.9	+70 36.3	16558	16557	+ 202	+47031	49862
			1902	+ 0 45.9	+70 35.5	16563	16562	+ 221	+47012	49844
			1903	+ 0 50.6	+70 35.5	16559	16557	+ 244	+46999	49832
			1904	+ 0 55.1	+70 35.6	16552	16550	+ 265	+46983	49815
			1905	+ 0 59.8	+70 36.1	16540	16538	+ 288	+46975	49799
			1906	+ 1 04.2	+70 36.6	16528	16525	+ 309	+46963	49784
			1907	+ 1 09.9	+70 37.7	16503	16500	+ 336	+46937	49754
			1908	+ 1 16.0	+70 38.6	16480	16476	+ 360	+46913	49723
			1909	+ 1 23.0	+70 40.4	16450	16445	+ 397	+46904	49705
			1910	+ 1 30.0	+70 41.9	16420	16414	+ 430	+46882	49675
			1911	+ 1 37.2	+70 43.9	16386	16379	+ 463	+46873	49656
			1912	+ 1 44.2	+70 46.0	16351	16343	+ 496	+46865	49636
			1913	+ 1 51.7	+70 48.5	16308	16299	+ 530	+46854	49609
			1914	+ 1 59.5	+70 51.6	16260	16250	+ 565	+46849	49592
			1915	+ 2 06.8	+70 54.9	16210	16199	+ 598	+46850	49576
			1916	+ 2 14.2	+70 58.3	16158	16146	+ 631	+46850	49559
			1917	+ 2 20.9	+71 01.6	16110	16096	+ 660	+46858	49550
			1918	+ 2 27.8	+71 04.9	16063	16048	+ 690	+46867	49544
			1919	+ 2 35.2	+71 07.9	16019	16003	+ 723	+46872	49534
			1920	+ 2 42.7	+71 11.2	15978	15960	+ 756	+46897	49546
			1921	+ 2 50.6	+71 14.2	15936	15916	+ 791	+46910	49543
			1922	+ 2 58.9	+71 17.3	15895	15873	+ 827	+46927	49547
			1923	+ 3 07.1	+71 20.0	15858	15835	+ 863	+46943	49547
			1924	+ 3 16.1	+71 23.3	15818	15792	+ 902	+46970	49563
			1925	+ 3 25.3	+71 27.1	15770	15742	+ 941	+47000	49575
			1926	+ 3 34.7	+71 31.5	15715	15684	+ 981	+47035	49591
			1927	+ 3 42.6	+71 34.8	15675	15642	+1014	+47068	49606
			1928	+ 3 50.4	+71 38.6	15630	15595	+1015	+47106	49630
			1929	+ 3 57.4	+71 42.3	15586	15549	+1075	+47145	49651
			1930	+ 4 04.5	+71 46.2	15539	15500	+1104	+47176	49669
			1931	+ 4 10.1	+71 48.8	15506	15465	+1127	+47199	49681
			1932	+ 4 17.1	+71 52.6	15466	15423	+1156	+47253	49719
			1933	+ 4 24.1	+71 55.7	15433	15387	+1184	+47299	49752
			1934	+ 4 30.5	+71 58.6	15405	15357	+1180	+47348	49790
			1935	+ 4 38.4	+72 02.2	15370	15320	+1243	+47404	49834
			1936	+ 4 45.3	+72 05.3	15336	15283	+1271	+47448	49865
Lovö	+59 21	17 50	1928	− 3 18.6	.. ....	15616	15590	− 902	.....	.....
			1929	− 3 08.3	+71 24.9	15582	15559	− 853	+46340	48890
			1930	− 2 58.5	+71 28.5	15548	15527	− 807	+46399	48935
			1931	− 2 49.7	+71 30.4	15525	15506	− 766	+46417	48944
			1932	− 2 40.2	+71 33.2	15492	15475	− 722	+46448	48963
			1933	− 2 30.8	+71 35.8	15467	15452	− 678	+46483	48989
			1934	− 2 21.3	+71 38.2	15442	15429	− 635	+46520	49016
			1935	− 2 11.4	+71 41.1	15412	15401	− 589	+46560	49045
			1936	− 2 02.2	+71 43.7	15388	15378	− 547	+46607	49082
			1937	− 1 53.0	+71 46.7	15365	15357	− 505	+46676	49140
			1938	− 1 44.2	+71 48.5	15348	15341	− 465	+46702	49159
			1939	− 1 36.3	+71 50.7	15328	15322	− 429	+46744	49193
Sitka[2]	+57 03	224 40	1902	+29 51.1	+74 47.8[1]	15440	13391	+7685	+56816[1]	58877
			1903	+29 54.0	+74 46.3[1]	15455	13398	+7704	+56773[1]	58839
			1904	+29 55.9	+74 45.4[1]	15473	13409	+7721	+56780[1]	58851
			1905	+29 59.2	+74 43.5	15490	13417	+7742	+56717	58794
			1906	+30 03.0	+74 41.1	15511	13426	+7767	+56640	58725
			1907	+30 07.2	+74 38.6	15526	13430	+7791	+56534	58627

[d]Earth-inductor adopted as standard produces a discontinuity of +3′ in I or +144γ from January 1, 1934, as compared with values of earlier years.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, + = N − = S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Sitka[2]—Continued......	+57 03	224 40	1908	+30 10.7	+74 36.8	15542	13436	+7812	+56473	58573
			1909	+30 13.4	+74 34.9	15556	13441	+7830	+56403	58509
			1910	+30 16.6	+74 32.4	15572	13448	+7851	+56306	58420
			1911	+30 19.3	+74 30.6	15585	13453	+7868	+56238	58358
			1912	+30 21.0	+74 28.9	15597	13460	+7881	+56174	58299
			1913	+30 22.0	+74 27.8	15603	13462	+7888	+56126	58254
			1914	+30 23.0	+74 26.7	15602	13459	+7891	+56052	58183
			1915	+30 23.2	+74 26.8	15588	13447	+7885	+56004	58133
			1916	+30 24.0	+74 25.9	15579	13437	+7884	+55917	58047
			1917	+30 24.9	+74 25.2	15577	13433	+7886	+55864	57995
			1918	+30 25.0	+74 24.3	15570	13427	+7883	+55785	57917
			1919	+30 26.8	+74 23.7	15569	13422	+7889	+55743	57876
			1920	+30 28.5	+74 22.3	15568	13417	+7896	+55655	57791
			1921	+30 28.7	+74 22.9	15564	13413	+7894	+55676	57811
			1922	+30 29.2	+74 22.6	15555	13404	+7892	+55626	57760
			1923	+30 29.0	+74 22.1	15549	13400	+7888	+55572	57706
			1924	+30 28.7	+74 22.0	15536	13389	+7880	+55521	57654
			1925	+30 27.0	+74 22.2	15524	13383	+7867	+55489	57620
			1926	+30 24.9	+74 22.8	15501	13368	+7848	+55447	57573
			1927	+30 22.8	+74 22.6	15491	13364	+7834	+55394	57519
			1928	+30 20.3	+74 22.7	15477	13358	+7818	+55352	57475
			1929	+30 17.5	+14 22.8	15465	13354	+7801	+55312	57433
			1930	+30 15.6	+74 22.8	15449	13344	+7785	+55256	57375
			1931	+30 13.1	+74 21.5	15454	13354	+7778	+55192	57315
			1932	+30 11.0	+74 21.0	15450	13355	+7768	+55150	57273
			1933	+30 08.3	+74 20.6	15450	13361	+7757	+55123	57247
			1934	+30 05.4	+74 20.4	15454	13371	+7748	+55126	57251
			1935	+30 02.7	+74 20.0	15450	13374	+7736	+55090	57215
			1936	+30 00.2	+74 19.8	15445	13375	+7723	+55058	57183
			1937	(+29 57.6)	(+74 19.7)	(15442)	(13379)	(+7712)	(+55039)	(57164)
			1938	(+29 55.5)	(+74 19.4)	(15442)	(13383)	(+7703)	(+55023)	(57149)
			1939	(+29 52.9)	(+74 19.1)	(15451)	(13397)	(+7698)	(+55039)	(57167)
Sverdlovsk............	+56 50	60 38	1900	+10 04.0	+70 40.3	17789	17505	+3109	+50718	53746
			1901	+10 08.6	+70 40.8	17778	17500	+3131	+50708	53735
			1902	+10 13.4	+70 44.2[e]	17763	17481	+3153	+50827	53842
			1903	+10 18.4	+70 45.6	17738	17452	+3174	+50821	53829
			1904	+10 22.9	+70 46.7	17721	17431	+3193	+50826	53827
			1905	+10 27.2	+70 48.3	17692	17398	+3210	+50819	53810
			1906	+10 31.0	+70 49.5	17664	17367	+3224	+50796	53779
			1907	+10 35.5	+70 52.2	17623	17323	+3239	+50806	53776
			1908	+10 39.8	+70 54.8	17581	17277	+3253	+50809	53765
			1909	+10 44.8	+70 57.6	17529	17222	+3269	+50794	53733
			1910	+10 48.7	+71 00.7	17476	17166	+3278	+50786	53708
			1911	+10 52.2	+71 04.4	17415	17103	+3284	+50785	53688
			1912	+10 54.7	+71 08.0	17356	17042	+3285	+50790	53673
			1913	+10 57.4	+71 12.1	17290	16975	+3286	+50792	53654
			1914	+11 00.1	+71 16.2	17219	16903	+3286	+50786	53626
			1915	+11 02.6	+71 21.2	17142	16825	+3288	+50797	53612
			1916	+11 03.8	+71 25.6	17070	16753	+3276	+50800	53592
			1917	+11 03.7	+71 29.8	17000	16684	+3262	+50796	53565
			1918	+11 03.3	+71 33.7	16936	16622	+3247	+50797	53547
			1919	+11 02.8	+71 38.1	16872	16559	+3233	+50823	53550
			1920	+11 01.9	+71 42.1	16812	16501	+3217	+50843	53551
			1921	+11 01.5	+71 46.1	16754	16445	+3204	+50865	53553
			1922	+11 01.4	+71 50.4	16692	16384	+3192	+50890	53558
			1923	+11 00.3	+71 54.2	16638	16332	+3176	+50915	53565
			1924	+11 00.8	+71 58.4	16578	16273	+3167	+50942	53571
			1925	+11 01.0	+72 03.0	16513	16209	+3156	+50974	53581
			1926	+11 01.0	+72 08.5	16443	16140	+3142	+51033	53619
			1927	+10 59.5	+72 12.2	16389	16088	+3125	+51053	53622
			1928	+10 58.5	+72 16.7	16335	16036	+3110	+51117	53664
			1929	+10 57.2	+72 20.3	16285	15988	+3094	+51145	53676
			1930[f]	+10 56.4	+72 24.2	16231	15936	+3080	+51178	53690
			1931[f]	+10 54.6	+72 26.9	16200	15907	+3066	+51220	53721
Vyssokaya Doubrava...	+56 44	61 04	1932	+12 49.9	+72 08.6	16312	15905	+3623	+50634	53197
			1933	+12 50.0	+72 11.5	16279	15872	+3616	+50676	53226
			1934	+12 50.4	+72 14.4	16248	15842	+3609	+50727	53266
			1935	+12 51.5	+72 17.7	16210	15804	+3607	+50781	53306
			1936	(+12 52.5)	(+72 21.1)	(16177)	(15770)	(+3605)	(+50848)	(53359)

[e]Earth-inductor adopted as standard in I produces discontinuity of about 3′.5 and corresponding changes in Z and F as compared with values of previous years.

[f]Observations discontinued at end of 1931; mean values for 1930 and 1931 derived from registrations at Vyssokaya Doubrava and absolute observations at Sverdlovsk.

Table 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, D	Inclination, I
	° ′	° ′		° ′	° ′
Rude Skov[g]	+55 51	12 27	1907	− 9 48.4	+68 44.0
			1908	− 9 41.7	+68 45.0
			1909	− 9 34.6	+68 43.9
			1910	− 9 27.1	+68 44.2
			1911	− 9 18.8	+68 44.8
			1912	− 9 10.6	+68 45.4
			1913	− 9 01.9	+68 46.6
			1914	− 8 52.0	+68 48.2
			1915	− 8 42.7	+68 50.6
			1916	− 8 33.0	+68 52.7
			1917	− 8 24.4	+68 54.7
			1918	− 8 15.5	+68 56.5
			1919	− 8 05.8	+68 58.2
			1920	− 7 55.6	+68 59.6
			1921	− 7 45.2	+69 01.2
			1922	− 7 33.8	+69 02.6
			1923	− 7 22.6	+69 03.6
			1924	− 7 10.4	+69 05.1
			1925	− 6 57.7	+69 07.2
			1926	− 6 45.2	+69 10.0
			1927	− 6 33.4	+69 11.6
			1928	− 6 22.0	+69 13.9
			1929	− 6 11.0	+69 16.2
			1930	− 6 00.4	+69 19.0
			1931	− 5 50.4	+69 20.5
			1932	− 5 39.9	+69 23.1
			1933	− 5 29.6	+69 25.0
			1934	− 5 19.3	+69 26.9
			1935	− 5 08.8	+69 29.5
			1936	− 4 58.9	+69 31.9
			1937	− 4 49.7	+69 34.4
			1938	− 4 40.3	+69 36.7
Zaymistche (Kasan, new site)	+55 50	48 51	[1]1914[h]	+ 8 21.3	+69 22.1
			[1]1915	+ 8 24.3	+69 28.8
			[1]1916	+ 8 27.9	+69 32.8
			[1]1917	+ 8 31.3	+69 37.1
			[1]1918[h]	+ 8 32.9	+69 43.9
			[1]1919[h]	+ 8 37.8	+69 45.6
			[1]1920[h]	+ 8 39.6	+69 48.1
			[1]1921[h]	+ 8 43.1	+69 56.5
			[1]1922[h]	+ 8 44.5	+70 00.2
			[1]1923	+ 8 50.4	+70 02.4
			[1]1924	+ 8 53.5	+70 07.6
			1925	+ 8 57.0	+70 12.2
			1926	+ 9 00.6	+70 18.3
			1927	+ 9 01.9	+70 22.5
			1928	+ 9 04.5	+70 27.4
			1929	+ 9 05.2	+70 31.6
			1930	+ 9 06.8	+70 36.3
			1931	+ 9 07.3	+70 38.6
			1932	+ 9 09.3	+70 42.9
			1933	+ 9 11.3	+70 46.5
			1934	+ 9 13.3	+70 50.5
			1935	+ 9 15.4	+70 53.2
			1936	(+ 9 18.0)	(+70 57.5)
Kasan	+55 47	49 08	1909	+ 8 05.1	+69 09.1
			1910	+ 8 03.3	+69 09.7
			1911	+ 8 04.5	+69 15.1
			1912	+ 8 09.1	+69 17.3
			1913	+ 8 10.9	+69 18.2
Kotchíno	+55 46	37 58	1926	+ 6 25.9	+68 51.1
			1927	+ 6 36.1	+68 59.5
Eskdalemuir	+55 19	356 48	1908[i]	−18 33.3	+69 37.3
			1909[i]	−18 30.1	+69 38.9
			1910[i]	−18 23.3	+69 37.8
			1911	−18 12.4	+69 37.1

Observatory	Year	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
		γ	γ	γ	γ	γ
Rude Skov[g]	1907	17423	17168	−2967	+44765	48036
	1908	17406	17157	−2931	+44759	48025
	1909	17386	17144	−2892	+44666	47930
	1910	17375	17139	−2853	+44648	47910
	1911	17359	17130	−2809	+44631	47888
	1912	17342	17120	−2767	+44610	47862
	1913	17319	17104	−2719	+44597	47842
	1914	17293	17086	−2665	+44592	47828
	1915	17257	17058	−2614	+44591	47814
	1916	17229	17038	−2561	+44599	47812
	1917	17198	17013	−2514	+44599	47798
	1918	17167	16989	−2466	+44587	47777
	1919	17144	16973	−2415	+44592	47774
	1920	17124	16960	−2361	+44596	47769
	1921	17105	16949	−2308	+44607	47774
	1922	17087	16938	−2242	+44615	47774
	1923	17073	16932	−2192	+44615	47771
	1924	17053	16920	−2130	+44621	47770
	1925	17025	16899	−2064	+44631	47768
	1926	16992	16874	−1998	+44654	47777
	1927	16974	16863	−1938	+44670	47785
	1928	16948	16843	−1879	+44691	47796
	1929	16924	16826	−1823	+44718	47813
	1930	16893	16800	−1768	+44747	47829
	1931	16879	16791	−1717	+44767	47844
	1932	16855	16773	−1664	+44805	47875
	1933	16839	16762	−1612	+44838	47896
	1934	16824	16751	−1560	+44875	47925
	1935	16804	16736	−1507	+44927	47967
	1936	16786	16723	−1458	+44972	48003
	1937	16767	16708	−1411	+45022	48042
	1938	16752	16696	−1364	+45071	48083
Zaymistche (Kasan, new site)	[1]1914[h]	17891	17701	+2600	+47517	50775
	[1]1915	17829	17638	+2606	+47635	50862
	[1]1916	17760	17567	+2614	+47619	50824
	[1]1917	17696	17501	+2622	+47630	50811
	[1]1918[h]	17640	17444	+2622	+47768	50921
	[1]1919[h]	17570	17371	+2636	+47651	50787
	[1]1920[h]	17530	17330	+2640	+47650	50772
	[1]1921[h]	17458	17256	+2646	+47813	50901
	[1]1922[h]	17401	17199	+2614	+47817	50885
	[1]1923	17367	17161	+2669	+47819	50875
	[1]1924	17310	17102	+2676	+47888	50920
	1925	17260	17050	+2685	+47951	50962
	1926	17191	16979	+2659	+48028	51010
	1927	17146	16933	+2658	+48086	51051
	1928	17091	16877	+2696	+48148	51091
	1929	17033	16819	+2690	+48168	51094
	1930	16982	16768	+2690	+48238	51140
	1931	16939	16725	+2685	+48215	51104
	1932	16892	16677	+2688	+48272	51142
	1933	16856	16640	+2692	+48336	51191
	1934	16830	16612	+2697	+48441	51281
	1935	16790	16571	+2701	+48460	51286
	1936	(16768)	(16548)	(+2710)	(+48594)	(51407
Kasan	1909	18118	17938	+2548	+47575	50908
	1910	18098	17919	+2536	+47547	50875
	1911	18052	17873	+2536	+47652	50956
	1912	18017	17835	+2555	+47651	50944
	1913	17959	17776	+2556	+47535	50815
Kotchíno	1926	17965	17852	+2012	+46442	49796
	1927	17875	17756	+2055	+46545	49859
Eskdalemuir	1908[i]	16830	15955	−5356	+45307	48332
	1909[i]	16835	15965	−5342	+45385	48407
	1910[i]	16836	15976	−5311	+45343	48368
	1911	16846	16002	−5263	+45344	48372

[g]Correction of +1′.6 has been made to published values of D for 1907 through 1920.
[h]No observations during: May, June, July, and August, 1914; August and September, 1918; January, February, and November, 1919; February and March, 1920; January, February, March, and April, 1921; February, 1922. [i]Two to five absolute observations per month.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, + = N − = S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Eskdalemuir—Continued	+55 19	356 48	1912	−18 03.9	+69 37.2	16846	16016	−5224	+45345	48374
			1913	−17 54.9	+69 37.3[i]	16822	16006	−5175	+45282[i]	48306[i]
			1914	−17 45.3	+69 36.1	16804	16004	−5124	+45188	48212
			1915	−17 35.9	+69 36.9	16786	16002	−5075	+45173	48191
			1916	−17 26.1	+69 37.6	16756	15986	−5020	+45119	48130
			1917	−17 16.3	+69 38.6	16732	15976	−4971	+45093	48097
			1918	−17 08.1	+69 39.0	16715	15973	−4925	+45067	48067
			1919	−16 58.7	+69 39.6	16713	15985	−4880	+45084	48082
			1920	−16 49.7	+69 39.5	16706	15990	−4836	+45062	48059
			1921	−16 37.3	+69 40.3	16695	15998	−4776	+45062	48055
			1922	−16 25.8	+69 40.0	16680	15999	−4718	+45012	48003
			1923	−16 13.8	+69 38.8	16676	16011	−4661	+44954	47947
			1924	−16 01.2	+69 38.7	16673	16025	−4601	+44938	47931
			1925	−15 48.4	+69 39.3	16665	16035	−4539	+44943	47933
			1926	−15 35.3	+69 40.3	16648	16035	−4474	+44939	47923
			1927	−15 22.7	+69 40.2	16631	16036	−4410	+44887	47869
			1928	−15 10.5	+69 41.2	16619	16039	−4350	+44894	47871
			1929	−14 58.9	+69 41.9	16603	16038	−4292	+44878	47851
			1930	−14 47.1	+69 43.2	16585	16036	−4232	+44881	47847
			1931	−14 34.8	+69 43.7	16583	16049	−4174	+44898	47863
			1932	−14 23.7	+69 45.0	16571	16051	−4120	+44916	47875
			1933	−14 12.1	+69 45.2	16558	16052	−4062	+44890	47847
			1934	−14 00.6	+69 45.9	16536	16044	−4003	+44859	47810
			1935	−13 48.8	+69 47.0	16525	16047	−3945	+44875	47822
			1936	(−13 37.4)	(+69 48.4)	(16517)	(16052)	(−3890)	(+44908)	(47849
			1937	(−13 26.9)	(+69 49.8)	(16506)	(16053)	(−3839)	(+44934)	(47870)
Meanook	+54 37	246 40	[l]1917	+27 46.1	.. ....	.....	.....	....	.....	.....
			1918	+27 44.3	+77 54.5	12938	11450	+6022	+60393	61763
			1919	+27 41.1	+77 54.2	12944	11463	+6014	+60400	61770
			1920	+27 38.6	+77 53.6	12923	11445	+5996	+60246	61617
			1921	+27 33.3	+77 53.7	12909	11444	+5971	+60190	61559
			1922	+27 28.5	+77 53.3	12904	11449	+5953	+60133	61502
			1923	+27 23.3	+77 53.2	12882	11439	+5925	+60031	61398
			1924	+27 17.7	+77 53.2	12866	11434	+5899	+59943	61308
			1925	+27 10.7	+77 53.8	12852	11433	+5870	+59934	61296
			1926	+27 04.2	+77 53.8	12832	11427	+5840	+59844	61205
			1927	+26 56.2	+77 53.7	12815	11425	+5806	+59756	61115
			1928	+26 48.5	+77 54.6	12794	11419	+5770	+59737	61092
			1929	+26 42.9	+77 55.1	12781	11417	+5746	+59721	61062
			1930	+26 39.2	+77 56.1	12755	11400	+5722	+59680	61023
			1931	+26 33.3	+77 55.0	12758	11412	+5704	+59601	60951
			1932	(+26 27.2)	(+77 54.6)	(12738)	(11405)	(+5674)	(+59466)	(60815)
			1933	(+26 21.9)	(+77 54.0)	(12736)	(11412)	(+5656)	(+59413)	(60761)
			1934	(+26 15.3)	(+77 53.5)	(12736)	(11422)	(+5634)	(+59367)	(60717)
			1935	(+26 08.2)	(+77 53.6)	(12732)	(11430)	(+5608)	(+59358)	(60708)
			1936	(+26 03.4)	(+77 53.1)	(12727)	(11433)	(+5590)	(+59291)	(60641)
			1937	(+25 59.6)	(+77 52.7)	(12729)	(11441)	(+5579)	(+59266)	(60618)
Hel	+54 36	18 48	1934	− 2 35.5	+68 25.2[l]	17553	17535	− 794	+44384	47729
			1935	− 2 25.2	.. ....	17530	17514	− 740	.....	.....
Stonyhurst[k]	+53 51	357 32	1900	−18 09.9	+68 50.3	17330	16448	−5402	+44720	47954
			1901	−18 08.6	+68 45.7	17361	16484	−5409	+44638	47891
			1902	−18 03.7	+68 46.2	17371	16500	−5384	+44678	47930
			1903	−18 00.6	+68 49.6	17382	16516	−5372	+44833	48079
			1904	−17 56.6	+68 48.2	17411	16544	−5366	+44845	48100
			1905	−17 51.3	+68 46.5	17381	16528	−5345	+44718	47972
			1906	−17 46.7	+68 48.1	17391	16540	−5304	+44792	48043
			1907	−17 41.6	+68 46.4	17400	16572	−5298	+44793	48052
			1908	−17 35.7	+68 44.2	17434	16619	−5270	+44801	48075
			1909	−17 28.5	+68 42.8	17425	16620	−5233	+44722	47996
			1910	−17 20.0	+68 42.2	17407	16617	−5186	+44654	47927
			1911	−17 13.2	+68 41.4	17412	16631	−5155	+44637	47912
			1912	−17 03.6	+68 41.4	17397	16633	−5104	+44601	47875
			1913	−16 55.5	+68 41.2	17374	16622	−5057	+44532	47802
			1914	−16 46.8	+68 39.6	17353	16613	−5009	+44416	47686
			1915	−16 38.0	+68 41.4	17342	16617	−4961	+44457	47720
			1916	−16 25.6	+68 41.9	17345	16638	−4905	+44483	47747
			1917	−16 16.4	+68 42.0	17340	16646	−4860	+44475	47737
			1918	−16 08.3	+68 43.3	17330	16647	−4818	+44501	47756

[i]From first five and last five months of 1913.

[k]Values for D and H depend on magnetograms using means of highest, lowest, 4 a. m. and 4 p. m. scalings; through 1908 all days, 1909 through 1918 ten quiet days, and from 1919 five international quiet days per month were used; I, X, Y, Z, and F are based on absolute observations (weekly for D and monthly for I and H).

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, + =N − =S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Stonyhurst[k] -Continued	+53 51	357 32	1919	−15 58.6	+68 43.1	17306	16618	−4758	+44376	47624
			1920	−15 52.9	+68 43.5	17303	16640	−4734	+44429	47679
			1921	−15 41.5	+68 43.0	17315	16670	−4683	+44449	47702
			1922	−15 30.9	+68 42.4	17305	16674	−4629	+44402	47655
			1923	−15 17.7	+68 41.6	17308	16695	−4566	+44377	47633
			1924	−15 05.3	+68 41.7	17276	16680	−4497	+44299	47547
			1925	−14 53.4	+68 42.2	17263	16683	−4436	+44282	47529
			1926	−14 39.7	+68 44.6	17240	16679	−4364	+44316	47550
			1927	−14 26.5	+68 43.5	17231	16687	−4297	+44251	47487
			1928	−14 14.5	+68 46.5	17209	16680	−4234	+44310	47534
			1929	−14 03.1	+68 46.2	17201	16686	−4177	+44275	47498
			1930	−13 51.1	+68 47.8	17190	16690	−4115	+44311	47530
			1931	−13 39.4	+68 47.3	17181	16697	−4057	+44271	47488
			1932	−13 28.0	+68 48.0	17176	16705	−4000	+44284	47498
			1933	−13 16.5	+68 49.0	17169	16708	−3942	+44297	47507
			1934	−13 04.9	+68 49.0	17163	16718	−3885	+44279	47487
			1935	−12 53.2	+68 50.7	17148	16716	−3824	+44311	47501
			1936	−12 38.3	+68 51.2	17154	16738	−3753	+44349	47551
			1937	−12 27.3	+68 52.2	17148	16743	−3698	+44370	47568
			1938	−12 17.7	+68 54.3	17150	16757	−3652	+44457	47651
Wilhelmshaven.........	+53 32	8 09	1886	−13 44.3	+67 59 3	17845	17334	−4238	+44142	47613
			1887	−13 38.6	+68 03.2	17865	17361	−4216	+44335	47800
			1888	−13 32.9	+68 01.0	17880	17382	−4189	+44291	47764
			1889	−13 27.9	+68 02.5	17898	17406	−4168	+44391	47864
			1890	−13 21.5	+67 59.9	17885	17401	−4132	+44263	47740
			1891	−13 14.8	+67 57.7	17899	17423	−4101	+44216	47702
			1892	−13 08.8	+67 57.3	17912	17443	−4074	+44235	47723
			1893	−13 03.1	+67 55.4	17941	17478	−4052	+44234	47735
			1894	−12 56.8	+67 56.6	17964	17507	−4025	+44337	47837
			1895	−12 50.5	+67 54.5	17985	17535	−3997	+44310	47821
			1896	−12 44.8	+67 51.7	17994	17551	−3970	+44229	47749
			1897	−12 39.6	+67 49.0	18028	17590	−3951	+44213	47747
			1898	−12 35.5	+67 47.4	18045	17611	−3934	+44196	47738
			1899	−12 29.9	+67 45.0	18072	17644	−3911	+44173	47728
			1900	−12 25.7	+67 44.0	18095	17671	−3894	+44193	47754
			1901	−12 22.2	+67 39.4	18121	17700	−3882	+44088	47667
			1902	−12 19.2	+67 41.8	18134	17716	−3869	+44208	47783
			1903	−12 14.8	+67 36.9	18144	17731	−3849	+44053	47644
			1904	−12 10.6	+67 41.5	18163	17754	−3831	+44268	47849
			1905	−12 06.2	+67 40.2	18169	17765	−3810	+44235	47821
			1906	−12 03.4	+67 39.3	18178	17777	−3797	+44224	47814
			1907	−11 57.4	.. ....	18215	17820	−3774	.....	.....
			1908	−11 52.1	+67 31	18171	17783	−3737	+43905	47516
			1909	−11 44.8	+67 30	18129	17749	−3691	+43767	47373
			1910	−11 37.0	+67 30.5	18124	17753	−3650	+43773	47377
			1911[l]	−11 28.2	+67 30.7	18110	17748	−3601	+43747	47347
			1931	− 7 54.5	+67 52.6	17826	17656	−2453	+43849	47334
			1932	− 7 42.9	+67 55.2	17815	17654	−2392	+43924	47399
Zouy (Irkutsk, new site).	+52 28	104 02	1915	+ 1 26.5	+70 58.5	19440	19434	+ 489	+56378	59635
			1916	+ 1 20.7	+71 02.5	19396	19391	+ 455	+56463	59701
			1917	+ 1 15.5	+71 03.6	19361	19356	+ 425	+56424	59654
			1918	+ 1 10.6	+71 04.6	19332	19328	+ 403	+56396	59617
			1919	+ 1 06.9	+71 05.8	19307	19303	+ 376	+56382	59596
			1920	+ 1 02.3	+71 06.6	19277	19274	+ 349	+56337	59543
			1921	+ 0 58.8	+71 08.2	19250	19247	+ 329	+56342	59540
			1922[m]	+ 0 55.4	+71 10.1	.....	.....	....	.....	.....
			1923[m]	.. ....	.. ....	.....	.....	....	.....	.....
			1924[m]	+ 0 49.2	+71 13.6	19170	19168	+ 274	+56397	59567
			1925	+ 0 45.5	+71 15.6	19143	19141	+ 253	+56427	59886
			1926	+ 0 42.9	+71 16.8	19115	19114	+ 239	+56412	59559
			1927[m]	+ 0 39.9	+71 16.9	19104	19103	+ 222	+56378	59528
			1928	+ 0 30.6	+71 17.8	19061	19060	+ 170	+56303	59442
			1929	+ 0 20.8	+71 19.2	19039	19039	+ 115	+56314	59445
			1930	(+ 0 17.7)	(+71 21.5)	(19019)	(19019)	(+ 98)	(+56380)	(59500)
			1931	(+ 0 14.3)	(+71 22.5)	(19029)	(19029)	(+ 79)	(+56460)	(59582)
			1932	.. ....	.. ....	.....	.....	....	.....	.....
			1933	(+ 0 05.1)	(+71 22.4)	(19013)	(19013)	(+ 28)	(+56409)	(59527)
			1934	(+ 0 01.0)	(+71 23.1)	(19013)	(19013)	(+ 6)	(+56447)	(59563)
			1935	(− 0 04.2)	(+71 24.4)	(19003)	(19003)	(− 23)	(+56490)	(59601)
			1936	(− 0 09.5)	(+71 27.1)	(18992)	(18992)	(− 52)	(+56599)	(59700)

[l] During 1912 to 1930 many interruptions prevented results.

[m] Account civil war observations temporarily discontinued in 1922 and not resumed until August 1924; values for 1924 include only August to December; values for 1927 include only January through June, observatory being under repairs for balance of that year.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, + =N − =S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Potsdam	+52 23	13 04	1900	− 9 56.3	+66 24.2[a]	18844	18561	−3252	+43138[a]	47074[a]
			1901	− 9 52.1	+66 22.8	18861	18582	−3232	+43128	47072
			1902	− 9 48.0	+66 20.8	18873	18598	−3212	+43090	47042
			1903	− 9 43.8	+66 20.0	18876	18604	−3190	+43070	47025
			1904	− 9 39.4	+66 19.6	18880	18612	−3167	+43065	47022
			1905	− 9 34.5	+66 19.3	18879	18616	−3140	+43050	47008
			1906	− 9 29.6	+66 18.4	18879	18620	−3114	+43022	46982
			1907	− 9 24.0	+66 19.0	18866	18613	−3081	+43010	46966
			1908	− 9 18.0	+66 19.3	18852	18604	−3047	+42990	46942
			1909	− 9 10.6	+66 19.7	18838	18597	−3004	+42973	46920
			1910	− 9 02.9	+66 19.7	18828	18594	−2961	+42948	46893
			1911	− 8 54.8	+66 20.0	18816	18589	−2915	+42930	46872
			1912	− 8 45.9	+66 20.5	18802	18582	−2865	+42916	46854
			1913	− 8 36.4	+66 21.4	18783	18571	−2811	+42904	46836
			1914	− 8 26.6	+66 22.9	18760	18557	−2755	+42901	46823
			1915	− 8 17.1	+66 25.1	18726	18531	−2698	+42899	46808
			1916	− 8 07.5	+66 27.1	18698	18510	−2643	+42904	46801
			1917	− 7 58.4	+66 29.2	18671	18491	−2590	+42912	46798
			1918	− 7 49.3	+66 30.9	18646	18473	−2538	+42913	46788
			1919	− 7 39.7	+66 32.3	18625	18459	−2483	+42913	46781
			1920	− 7 29.4	+66 33.5	18606	18447	−2425	+42912	46772
			1921	− 7 18.9	+66 34.5	18591	18440	−2367	+42911	46765
			1922	− 7 07.7	+66 35.7	18576	18432	−2305	+42918	46766
			1923	− 6 56.9	+66 36.5	18565	18429	−2246	+42919	46762
			1924	− 6 45.0	+66 38.0	18550	18422	−2180	+42935	46771
			1925	− 6 33.0	+66 39.7	18532	18411	−2114	+42951	46779
			1926	− 6 20.6	+66 42.6	18505	18389	−2044	+42982	46795
			1927	− 6 09.1	+66 44.0	18489	18383	−1981	+43012	46808
			1928	− 5 58.2	+66 45.8	18467	18367	−1919	+43010	46806
Seddin	+52 17	13 01	1908	− 9 19.2	+66 16.2	18890	18641	−3059	+42974	46942
			1909	− 9 12.0	+66 16.7	18876	18633	−3018	+42958	46922
			1910	− 9 04.3	+66 16.6	18866	18630	−2975	+42933	46896
			1911	− 8 55.8	+66 17.0	18853	18624	−2927	+42916	46875
			1912	− 8 47.3	+66 17.4	18840	18619	−2878	+42901	46856
			1913	− 8 37.9	+66 18.4	18822	18609	−2825	+42891	46839
			1914	− 8 28.1	+66 19.9	18798	18593	−2768	+42887	46826
			1915	− 8 18.6	+66 22.1	18765	18568	−2712	+42885	46810
			1916	− 8 09.0	+66 24.1	18736	18547	−2656	+42890	46804
			1917	− 7 59.8	+66 26.1	18711	18529	−2603	+42898	46801
			1918	− 7 50.8	+66 27.7	18687	18512	−2551	+42899	46792
			1919	− 7 41.3	+66 29.4	18663	18495	−2497	+42899	46783
			1920	− 7 31.2	+66 30.6	18645	18485	−2440	+42899	46776
			1921	− 7 20.5	+66 31.6	18629	18476	−2380	+42898	46768
			1922	− 7 09.4	+66 32.8	18614	18469	−2319	+42905	46769
			1923	− 6 58.6	+66 33.6	18603	18465	−2260	+42906	46765
			1924	− 6 46.8	+66 35.0	18589	18459	−2194	+42922	46774
			1925	− 6 34.7	+66 36.8	18570	18448	−2127	+42938	46782
			1926	− 6 22.3	+66 39.7	18539	18425	−2058	+42968	46797
			1927	− 6 10.9	+66 41.1	18526	18419	−1995	+42987	46810
			1928	− 5 59.6	+66 42.8	18505	18403	−1932	+42995	46808
			1929	− 5 49.1	+66 45.6	18480	18385	−1874	+43034	46834
			1930	− 5 38.6	+66 48.3	18456	18367	−1815	+43072	46860
			1931	− 5 28.9	+66 49.8	18450	18365	−1762	+43106	46888
Irkutsk (Old site)	+52 16	104 16	1900	+ 2 01.3	+70 14.8	20129	20116	+ 710	+56053	59558
			1901	+ 2 00.8	+70 16.7	20116	20104	+ 707	+56114	59610
			1902	+ 2 00.4	+70 18.5	20098	20086	+ 704	+56156	59644
			1903	+ 1 59.9	+70 21.4	20068	20056	+ 700	+56220	59694
			1904	+ 1 59.4	+70 22.7	20043	20031	+ 696	+56220	59686
			1905	+ 1 58.1	+70 25.0	20011	19999	+ 687	+56250	59703
			1906	+ 1 56.7	+70 26.8	19983	19971	+ 678	+56264	59707
			1907	+ 1 55.7	+70 29.5	19940	19929	+ 671	+56283	59711
			1908	+ 1 54.9	+70 31.6	19901	19890	+ 665	+56281	59696
			1909	+ 1 51.3	+70 33.5	19860	19850	+ 643	+56265	59667
			1910	+ 1 47.0	+70 36.0	19824	19814	+ 617	+56293	59682
			1911	+ 1 41.5	+70 38.4	19785	19776	+ 584	+56308	59683
			1912	+ 1 35.2	+70 39.2	19754	19746	+ 547	+56262	59629
			1913	+ 1 29.7	+70 40.4	19715	19708	+ 514	+56213	59570
			1914	+ 1 24.6	+70 43.8	19671	19665	+ 484	+56266	59606
			1915[b]	+ 1 27.0	+70 45.8	19621	19615	+ 497	+56228	59554
			1916[b]	+ 1 21.2	+70 47.8	19577	19571	+ 462	+56207	59517
			1917[b]	+ 1 16.0	+70 48.9	19542	19537	+ 432	+56164	59463
			1918[b]	+ 1 11.0	+70 49.9	19513	19509	+ 403	+56134	59428
			1919[b]	+ 1 07.4	+70 51.0	19488	19484	+ 382	+56120	59409
			1920[b]	+ 1 02.8	+70 51.9	19458	19455	+ 355	+56081	59360

[a] I, Z, and F slightly uncertain. [b] Values for 1915 to 1920 are based on results at Zouy corrected for station-differences as follows: D, +0′.5; I, −14′.7; H, +181γ.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, + =N − =S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Swider[p]	+52 07	21 15	1921	− 3 30.3	+66 34.4	18712	18677	−1144	+43185	47065
			1922	− 3 20.7	+66 36.7	18690	18658	−1091	+43215	47084
			1923	− 3 09.6	+66 39.4	18674	18646	−1029	+43269	47127
			1924	− 2 58.0	+66 41.9	18649	18624	− 965	+43300	47146
			1925	− 2 46.6	+66 45.0	18620	18598	− 913	+43339	47170
			1926	− 2 35.1	+66 48.3	18584	18565	− 838	+43369	47183
			1927	− 2 25.2	+66 50.3	18563	18546	− 784	+43390	47194
			1928	− 2 15.3	+66 54.2	18536	18522	− 729	+43464	47252
			1929	− 2 06.3	+66 57.6	18507	18495	− 680	+43517	47289
			1930	− 1 57.3	+67 01.1	18476	18465	− 630	+43565	47321
			1931	− 1 49.1	+67 03.2	18463	18454	− 586	+43608	47356
			1932	− 1 39.9	+67 05.7	18438	18430	− 535	+43639	47374
			1933	− 1 31.9	+67 09.3	18420	18413	− 492	+43724	47445
			1934	− 1 23.7	+67 11.5	18406	18401	− 448	+43768	47481
			1935	− 1 15.2	+67 15.1	18384	18380	− 402	+43845	47543
De Bilt (Succeeding Utrecht)	+52 06	5 11	1899	−13 54.7	+67 02	18502	17959	−4448	+43660[q]	47410
			1900	−13 50.6	+66 57	18508	17970	−4428	+43490[q]	47260
			1901	−13 46.2	+66 54	18524	17992	−4409	+43440[q]	47230
			1902	−13 42.3	+66 52.8	18547	18019	−4394	+43450[q]	47240
			1903	−13 37.2	+66 51.4	18556	18034	−4370	+43410[q]	47210
			1904	−13 32.7	+66 49.2	18561	18045	−4347	+43350[q]	47150
			1905	−13 28.5	+66 48.5	18560	18049	−4325	+43320[q]	47130
			1906	−13 24.2	+66 53.3	18569	18063	−4304	+43510[q]	47310
			1907	−13 19.0	+66 49.9	18559	18060	−4275	+43370[q]	47170
			1908	−13 12.8	+66 47.2	18551	18060	−4240	+43260[q]	47070
			1909	−13 06.5	+66 47.8	18544	18061	−4206	+43260[q]	47070
			1910	−12 58.2	+66 46.5	18541	18068	−4161	+43208	47017
			1911	−12 50.7	+66 45.4	18540	18076	−4122	+43167	46980
			1912	−12 41.7	+66 46.5[r]	18537	18084	−4074	+43200	47009
			1913	−12 32.1	+66 45.9	18525	18083	−4021	+43151	46958
			1914	−12 22.6	+66 46.5	18512	18082	−3968	+43140	46944
			1915	−12 12.5	+66 48.0	18481	18063	−3908	+43117	46913
			1916	−12 02.7	+66 48.8	18461	18055	−3852	+43101	46888
			1917	−11 53.6	+66 50.1	18443	18047	−3801	+43103	46883
			1918	−11 44.0	+66 50.7	18424	18039	−3747	+43081	46860
			1919	−11 34.3	+66 51.5	18410	18036	−3693	+43075	46840
			1920	−11 24.2	+66 51.8	18397	18034	−3637	+43056	46820
			1921	−11 13.6	+66 52.6	18389	18037	−3580	+43065	46830
			1922	−11 01.9	+66 52.8	18382	18042	−3517	+43054	46810
			1923	−10 50.2	+66 52.6	18378	18051	−3456	+43038	46800
			1924	−10 38.3	+66 52.7	18372	18056	−3392	+43024	46780
			1925	−10 25.4	+66 53.5	18359	18056	−3322	+43026	46780
			1926	−10 13.1	+66 55.5	18337	18046	−3253	+43040	46780
			1927	−10 01.0	+66 55.9	18330	18050	−3188	+43041	46782
			1928	− 9 48.8	+66 57.4	18313	18045	−3121	+43053	46786
			1929	− 9 37.3	+66 58.6	18300	18042	−3059	+43063	46790
			1930	− 9 26.3	+67 00.4	18282	18034	−2998	+43084	46802
			1931	− 9 15.7	+67 00.8	18278	18039	−2942	+43089	46804
			1932	− 9 04.2	+67 02.3	18264	18036	−2879	+43107	46818
			1933	− 8 53.1	+67 03.0	18258	18039	−2820	+43115	46824
			1934	− 8 43.0	+67 03.7	18254	18043	−2766	+43132	46836
			1935	− 8 31.9	+67 05.4	18244	18042	−2707	+43169	46865
			1936	− 8 21.4	+67 06.9	18236	18042	−2650	+43202	46893
			1937	− 8 11.8	+67 08.4	18228	18042	−2599	+43237	46924
Utrecht (Superseded by De Bilt)	+52 05	5 11	1891	−14 37.1	+67 15	18354	17760	−4632	+43769	47462
			1892	−14 34.5	+67 14	18376	17785	−4624	+43786	47486
			1893	−14 28.5	+67 12	18398	17814	−4599	+43767	47477
			1894	−14 21.1	+67 10	18416	17841	−4565	+43739	47458
			1895	−14 15.5	+67 07	18435	17867	−4540	+43677	47408
			1896	−14 09.7	+67 04	18448	17887	−4513	+43602	47344
			1897	−14 05.2	.. ....	.....	.....	....	.....	.....
			1898	−13 59.1	+67 02	18487	17939	−4468	+43623	47379
Niemegk (Succeeding Seddin)	+52 04	12 40	1931	− 5 36.2	+66 41.6	18526	18437	−1809	+43003	46824
			1932	− 5 26.3	+66 42.9	18518	18435	−1755	+43029	46845
			1933	− 5 15.1	+66 44.6	18507	18429	−1694	+43064	46872
			1934	− 5 05.2	+66 46.9	18491	18418	−1639	+43106	46905
			1935	− 4 54.9	+66 49.4	18477	18409	−1583	+43159	46948
			1936	− 4 45.3	+66 52.1	18464	18400	−1531	+43220	46999
			1937	− 4 35.8	+66 54.8	18449	18390	−1478	+43284	47051
			1938	− 4 27.1	+66 57.3	18437	18381	−1431	+43339	47098

[p]Built in 1914 but because of first world war not functioning regularly until 1921. [q]Note values given to nearest ten γ only. [r]Schulze earth-inductor replaced Dover dip-circle in 1912.

(*To be continued in September number*)

tables and computing machines were used for the following relationships, paying attention to the conventions that all values are referred to the north-seeking end of the needle considering east declination, north inclination, horizontal component, north component (X), east component (Y), total component (F), and vertical component directed downward as positive [+] and west declination, south inclination, west component, and vertical component directed upward as negative [−].

$$X = H \cos D \qquad Y = H \sin D \qquad X^2 + Y^2 = H^2$$
$$Z = H \tan I \qquad F = H \sec I \qquad H^2 + Z^2 = F^2$$
$$X^2 + Y^2 + Z^2 = F^2$$

For convenience, the values of declination and inclination are given to the $0'.1$ and the values of the components in intensity to the nearest 0.00001 CGS unit ($=1\gamma$). It must be noted that for some of the observatories the control of base-lines and absolute standards, of scale-values, and of correctness in orientation of the needles of the intensity-variometers does not guarantee these orders of accuracy.

It is difficult to condense within the limits of a summarized tabulation the many notes necessary as regards procedures, methods, and standards and their inevitable changes in the course of many years of operation. The more general types of notes are indicated in Table 1 by superior numbers or by parenthetical or bracketed enclosures in the body of the Table as follows:

[1] = Results based on absolute observations only.
[2] = Results based on records for all days.
[3] = Results based on five internationally selected quiet days.
[4] = Results based on records for ten selected least disturbed days.
( ) = Preliminary results.
[ ] = Interpolated results.
— = A break occurred between the preceding and following years.
* = Observatory so marked is in a region of local magnetic disturbance.

More special notes applying to individual observatories are indicated by superior letters and their meanings are given in the corresponding footnotes at the bottom of each page.

The authors are indebted to their late colleague, C. C. Ennis, who began (a) the exacting and laborious task of checking the values originally given and corrections subsequently made in the publications of the observatories and (b) the necessary computations for those elements and components not given in the publications. These tasks had been about 40 per cent completed at the time of Mr. Ennis' death on November 24, 1941.

Table 2, to follow the concluding part of Table 1, will list all permanent geomagnetic observatories operating now or in the past and many stations at which series of magnetograph records were obtained for at least the better part of a year by special expeditions, for example, the two International Polar Years of 1882-83 and 1932-33. It will be an extension, with corrections and additions, of similar tables given by Adolf Schmidt[5] and Sydney Chapman and Julius Bartels.[6] It will list

[5]Ad. Schmidt, Archiv des Erdmagnetismus, Heft 4, Potsdam (1926).
[6]S. Chapman and J. Bartels, Geomagnetism, 2, T1-T5, Oxford (1940).

geographic and geomagnetic coordinates. The latter will be relative to the geomagnetic north pole in latitude 78°.5 north and longitude 291° east and the corresponding geomagnetic equator. Geographic (as in Table 1) and geomagnetic (Φ) latitudes are indicated as positive [+] for northern and negative [−] for southern hemispheres. Geographic and geomagnetic (Λ) longitudes are all east. Φ is the angular distance from the geomagnetic equator and Λ is the angle between the meridian extending southward from the geomagnetic north pole and the great circle through it and the station; the angle (ψ) formed by this great circle with the geographic meridian of the station, considered as positive eastward, will be included in Table 2.

Just as page-proof was completed the following additional data for Lerwick and Eskdalemuir were received from Director G. C. Simpson of the Air Ministry, Meteorological Office, London:

Table 1—*Annual values of geomagnetic elements at observatories*—Continued

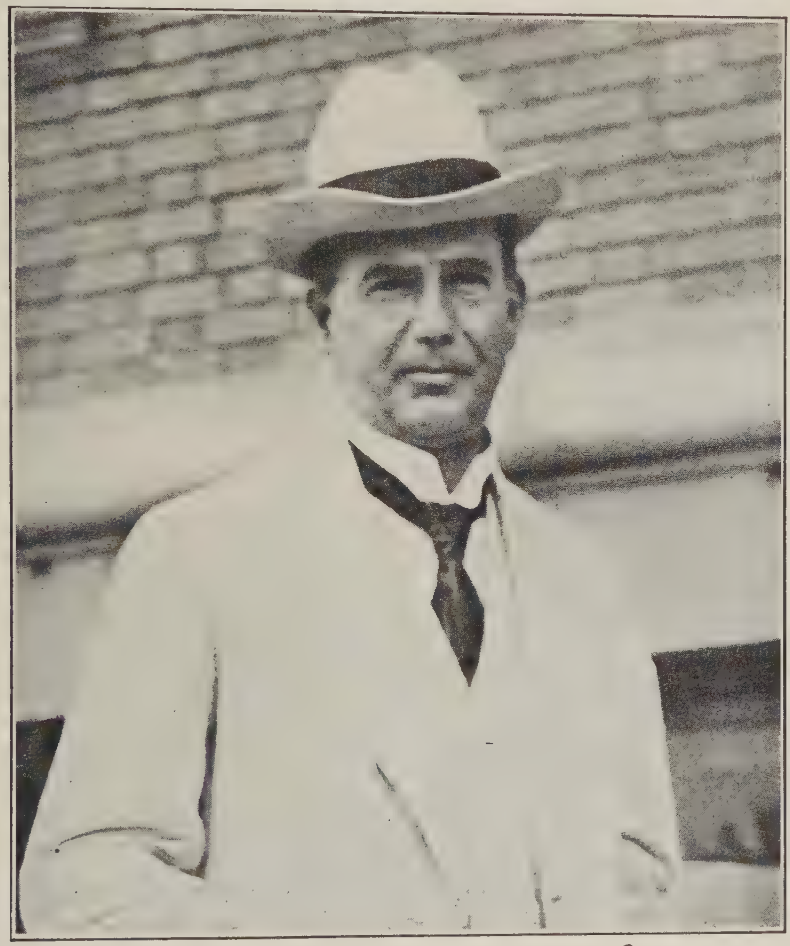
Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Lerwick..............	+60 08	358 49	1938	−12 35.8	+72 54.4	14402	14056	−3141	+46837	49001
			1939	−12 25.7	+72 55.2	14395	14058	−3098	+46850	49011
			1940	−12 15.3	+72 56.0	14390	14062	−3055	+46873	49032
			1941	−12 05.2	+72 56.9	14383	14064	−3012	+46893	49049
			1942	−11 56.7	+72 56.8	14387	14076	−2978	+46904	49061
Eskdalemuir...........	+55 19	356 48	1938	−13 17.1	+69 50.7	16504	16062	−3792	+44967	47900
			1939	−13 07.3	+69 51.1	16507	16076	−3748	+44991	47923
			1940	−12 57.9	+69 51.8	16508	16088	−3704	+45022	47953
			1941	−12 48.2	+69 52.5	16508	16097	−3658	+45051	47980
			1942	−12 39.8	+69 51.9	16518	16116	−3621	+45053	49985

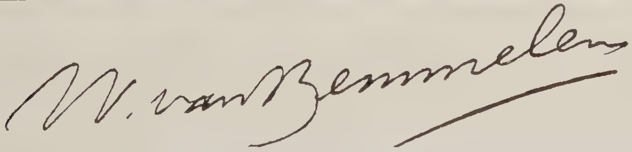
In spite of every precaution there doubtless may be some corrections necessary in so extensive tables of data; it is asked that information regarding these be supplied promptly by the directors of various observatories in order that when the post-war final "List of observatories and thesaurus of values" is prepared it will be as free from error as possible. Corrections and especially suggestions for improvement of the "List" will be welcomed by the authors whose aim to make this revision as reliable as possible may thus be the more assured.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, 15, D. C., June 14, 1943

WILLEM VAN BEMMELEN, 1868-1941

Dr. Willem van Bemmelen, preeminent investigator in geomagnetism in the earlier years of the twentieth century, died in Holland on January 28, 1941.* Born at Groningen on August 26, 1868, the son of Dr. J. M. van Bemmelen, Professor of Chemistry at the University of Leiden, he





*Information regarding the death of Dr. van Bemmelen was not received by the JOURNAL until May 1943 because of delays in the mails. Unfortunately we cannot contact Dr. van Bemmelen's colleagues in Holland for a more suitable account of his life and work. This note is based largely upon the obituary by C. E. P. Brooks [London, Q. J. R. Met. Soc., **68**, 194 (1942)] to which reference may be made for more details of van Bemmelen's activities in meteorology.—*Ed.*

was awarded his doctorate by that University in 1893. He was made Assistant Director of the Royal Netherlands Meteorological Institute at Utrecht in 1892 and was transferred to the Royal Magnetical and Meteorological Observatory at Batavia, Java, in 1898 and served as Director of the Observatory from 1905 to 1922. On his return to Holland in 1920, he became Lecturer in Physical Geography at the University of Amsterdam and held this position until his retirement in 1938. We are indebted to the Department of Terrestrial Magnetism of the Carnegie Institution for the photograph made at Washington, D. C., in June 1922 while he was en route home and visiting his long-time friend and colleague, Dr. Louis A. Bauer.

Van Bemmelen's investigations covered a wide range in geophysics, including meteorology, seismology, volcanology, and terrestrial magnetism, and dealt both with the fundamental and practical aspects. Outstanding among his publications are the year-books and monographs of the Batavia Royal Magnetical and Meteorological Observatory during his Directorship and especially so those bearing on geomagnetism.

His thesis for the doctorate dealt with the secular variation of terrestrial magnetism. Later researches were concerned with magnetic disturbances (sudden commencements and the diurnal field), lunar variation, eclipse effects, and geomagnetic surveys. In 1908 he completed a geomagnetic survey of the Dutch East Indies. He was among the first to study post-perturbation and pulsations. He contributed frequently on various aspects of terrestrial magnetism to the early numbers of the JOURNAL.

Partial list of geomagnetic publications

De isogonen in de XVI^{de} en XVII^{de} eeuw. Utrecht, J. van Druten, 1893 (48 pp. with maps).

Die Linien gleicher Säkular-Variation der Deklination. Amsterdam, Proc. K. Akad. Wet., 1895, 6 pp.

Die erdmagnetische Nachstörung. Met. Zs., 321-329, Sep. 1895.

Magnetische Beobachtungen in der Schweiz in den Jahren 1896 und 1897 ausgeführt (with E. van Rijckevorsel). Amsterdam, H. G. Bom's Seefahrt-Buchhandlung, 1899 (36 pp. with maps).

Werte der erdmagnetischen Deklination für die Periode 1500-1700, und ihrer Säkular-Variation für die Periode 1500-1850. Amsterdam, Proc. K. Akad. Wet., 390-400, 1897.

Die Abweichung der Magnetnadel: Beobachtungen, Säkular-Variation, Wert- und Isogonensysteme bis zur Mitte des XVIIIten Jahrhunderts. Batavia, Obsns. R. Mag. Obs. (Supp.), **21,** 1899 (109 pp. with charts).

The magnetic "postturbation" and the current vortices of Schmidt. Terr. Mag, **5,** 123-126 (1900).

Die Säkular-Verlegung der magnetischen Axe der Erde. Batavia, Obsns. Mag. Met. Obs., **22,** App. I, 1900 (30 pp.).

Erdmagnetische Pulsationen. Batavia, Nat. Tijdschr., **62,** 71-88 (1902).

The daily field of magnetic disturbance. Amsterdam, Proc. Sci. K. Akad. Wet., 227-251 and 313-319, 1903. Also Terr. Mag., **8,** 153-174 (1903).

Contribution to the knowledge of the influence of solar eclipses on terrestrial magnetism. Batavia, Nat. Tijdschr., **64,** 30 pp. (1905).

On magnetic disturbances as recorded at Batavia. Amsterdam, Proc. Sci. K. Akad. Wet., 266-278, 1906.

On pulsations. Obsns. R. Mag. Met. Obs., **29,** App., 1908 (10 pp.).

Registration of earth-currents at Batavia for the investigation of the connection between earth-current and force of earth-magnetism. Amsterdam, Proc. Sci. K. Akad. Wet., 512-533, 782-789, and 242-248, 1908.

The starting impulse of magnetic disturbance. Amsterdam, Proc. Sci. K. Akad. Wet., 773-782, 1908.

Magnetic survey of the Dutch East-Indies made in the years 1903-1907. Obsns. R, Mag. Met. Obs., **30**, App. 1, 1909 (70 pp. with plates).

Die lunare Variation des Erdmagnetismus. Met. Zs., **29**, 218-230 (1912) and **30**, 589-594 (1913).

Een wereldwerk voor aardmagnetisme en atmosferische electriciteit. Utrecht, Natuur, **41**, 1-8 (1921).

Nachstörung, Aktivität und interdiurne Veränderlichkeit der Horizontalkomponente beim Erdmagnetismus. Met. Zs., **42**, 143-147 (1925).

De kompaswaarnemingen der oude zeevaarders en verplaatsing der magnetische pool. Amsterdam, Tijdschr., K. Ned. Aadr. Gen., **42**, 508-519 (1925).

NOTES

(See also page 92)

15. *Personalia*—Vice-Admiral *John A. Edgell*, Hydrographer of the Royal Navy, distinguished for the organization and encouragement of work in tidal research, in determining gravity at sea and in magnetic and electric survey of the oceans, was elected to fellowship in the Royal Society of London, March 18, 1943. *William M. H. Greaves*, Astronomer Royal of Scotland, distinguished for his contributions to stellar spectrophotometry and who has made important studies of the relationships of magnetic storms and solar activity was also elected to fellowship in the Society at the same time.

E. H. Bramhall was succeeded May 1, 1943, as Observer-in-Charge of the College Observatory of the Carnegie Institution of Washington in cooperation with the University of Alaska by *S. L. Seaton*. Dr. Bramhall reported for other important responsibilities in Washington on May 26, 1943. *Ernst Wolff* and *Rodney Ohlsen* continue as Senior Observer and Observer at the College Observatory.

Stanley W. Totten has been assigned as Assistant Observer to the Sitka Magnetic Observatory of the United States Coast and Geodetic Survey under Observer-in-Charge *H. W. Pinckney*.

Dr. *Merle Antony Tuve*, Chief Physicist, Department of Terrestrial Magnetism, Carnegie Institution of Washington, was elected to resident membership in the American Philosophical Society, at the annual general meeting held in April, 1943.

Dr. *Charles Frederick Marvin*, who was connected with the United States Weather Bureau from 1891 to 1934, being Chief of that Bureau from 1913 to his retirement in 1934, died at Washington, June 5, 1943, at the age of 84 years.

REVIEWS AND ABSTRACTS

E. SUCKSDORFF, *Die erdmagnetische Aktivität in Sodankylä in den Jahren 1914-1934.* Veröffentlichungen des Geophysikalischen Observatoriums der Finnischen Akademie der Wissenschaften Nr. 25, Kuopio, Osakyntiö Kirjapaino Sanan Valta, 68 pp, 21 figs., 41 tables (1942). 32 cm.

The geographic distribution and variations of geomagnetic activity are imperfectly known. It is known, however, that magnetic activity increases with increasing magnetic latitude up to the zone of maximum auroral frequency and then decreases towards the poles. For an investigation of the general magnetism of the Earth, it is important to have detailed information regarding the magnetic activity at various points on its surface. Such investigations, because of the great labor involved, cannot be undertaken at all observatories; the requisite information, however, obtained from the records of observatories suitably situated in various parts of the Earth is sufficient for the purpose. The Sodankylä Observatory is especially favored by its location near the auroral zone, its geomagnetic position being $\Phi=63°.8$, $\Lambda=120°.0$. Moreover, this Observatory has been in operation since 1914, except for a few months in 1918.

The present investigation of the geomagnetic activity at Sodankylä embraces the years 1914-1934, or about two sunspot-cycles. In the greater part of the discussion, the year 1918 whose registration is incomplete, was disregarded.

The hourly variation of the vertical component of the Earth's field, less the amount attributable to the regular diurnal variation of this element on specially selected quiet days, was taken as the measure of activity. These differences were multiplied by 1/10,000 of the mean value of the vertical component in gammas according to the equation $AZ=Z(r_z-r_{z_q})\times10^{-4}$, where r_z is the hourly variation of Z. The value of the activity thus obtained was designated AZ.

The years under investigation were divided, on the basis of their mean activity, into three groups—quiet, moderately disturbed, and greatly disturbed. Besides these annual activity-groups, in which the degrees of activity differ distinctly from one another, the variations of activity are also treated in three groups of years based on the periodicity of solar activity. Magnetic activity is investigated on the basis of seasons instead of years. The most important results obtained in this way are as follows:

The mean activity obtained for the whole period under examination was $AZ=131$. The year 1930 was considerably more active than any of the other years ($AZ=244$) and the years 1914 and 1924 were the most quiet ($AZ=64$ and 62, respectively).

The correlation of annual means of AZ with the other numbers commonly used to express geomagnetic activity and above all with the international magnetic character-figures, as well as the mean annual amplitudes of the daily range of the magnetic elements at Sodankylä, was found to be particularly high during the years under consideration. It is of interest to note the author's statement that only in the case of the Potsdam u-numbers a notable disagreement with the AZ-values was observed. The correlation-coefficient between the annual u- and AZ-means for 1914-1934 is given as 0.56 ± 0.10. The correlation between the annual means of the AZ-values and the relative sunspot-numbers was only 0.34 and between the monthly means of the numbers it was even smaller. A similarly small correlation was likewise found on comparing the other numbers for solar activity with the AZ-numbers. During the first sunspot-cycle of the period investigated, the correlation was considerably higher than in the second. Moreover, it was established that the cycle of the annual values of magnetic activity as expressed by AZ lagged one to two years behind the sunspot-numbers.

In the contribution to the mean AZ-values and the periodic changes of the activity, the magnetic disturbances of all magnitudes take part. In this the number of disturbed hours and the magnitude of the disturbances both contribute, the latter of the two factors being the more important with increasing activity. On the average 24 per cent of all hours have the same or a higher AZ-value than the corresponding monthly or annual means of the activity. Out of all hours in the quiet years on the average 15 per cent and in the greatly disturbed years 28 per cent must be designated as agitated or disturbed ($AZ>140$). Really disturbed hours ($AZ>750$) occur in the quiet years on two

per cent and in the very disturbed years on five per cent of all hours. The greatest disturbances ($AZ>3000$) are very rare in the quietest years and they occur only occasionally in the remaining years. Absolutely quiet hours ($AZ=0$) in the quiet years total about eight per cent and in the very disturbed years about five per cent of all hours.

The yearly curve of geomagnetic activity is represented by two six-month waves, of which the maxima fall in March and October and the minima in July and at the end of the year. In the quiet and moderately disturbed years the autumnal maximum is the larger, whereas in disturbed years the vernal maximum is greater. On the average for all years the autumnal is a little higher than the vernal maximum. The summer minimum is larger than the winter minimum. The increase of activity (apart from the augmentation of the mean annual value) affects the vernal wave whose amplitude it augments while the amplitude of the second six-month wave remains practically unchanged. The effect of strong disturbance is especially effective near the spring maximum. The increase in activity effects, moreover, a displacement of the two waves of the annual curve, which amounts to about one-half month between the quiet and very disturbed groups of the years. On the average the wholly quiet hours are most numerous in winter and rarest in summer. The great storms occur mostly about the equinoxes and are least common in summer.

In the two principal waves of the annual curve there occur two or three rather weak peaks, of which the one occurring in May in quiet years is valid in the opinion of the author. These secondary waves are most distinct in quiet years, they become weaker with increasing activity and occur earlier. In midwinter a rather weak secondary wave occurs.

The daily course of geomagnetic activity is represented by a very regular single-wave, with the maximum shortly before local midnight and the minimum a little before noon. The increase of activity produces an increase in amplitude in the diurnal-variation wave which is approximately proportional to the average activity. The reason for this is that the disturbed hours, especially the great disturbances, are concentrated around midnight. About ten per cent of all days are disturbed ($AZ>750$) during the intervals corresponding to the daily maximum.

The more disturbed the hours, the rarer their occurrence about the time of the daily minimum. The largest disturbances do not occur near the minimum. An increase in activity causes an advance of the daily maximum and a delay of the minimum while the wave as a whole is retarded. The maximum occurs earliest in winter and latest in summer. In general the curve of the daily course in summer is about 1½ hours later than in winter.

Besides the principal wave of the daily curve there is, especially in summer, in the afternoon half of the day, a tendency towards a weak secondary wave.

There was found to be a distinct tendency of the magnetically disturbed and likewise of the quiet days to recur after the lapse of 27 days or one solar rotation. Moreover there was found a tendency for a recurrence-period of about 14 days.

The international quiet and disturbed days behave, in every respect, apart from the different large amplitudes of the changes, in a manner similar to all days.

It is to be hoped that similar careful studies of geomagnetic activity may be undertaken at other observatories and thus increase our knowledge of this important subject.

H. D. HARRADON

CIRCULAR LETTER TO MEMBERS OF THE COMMISSION OF TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY OF THE INTERNATIONAL METEOROLOGICAL ORGANIZATION

Lausanne, le 23 mars 1943

Monsieur et très honoré Collègue:

Comme suite à ma circulaire no. 170 du 21 juillet 1942, adressée aux 31 membres de la Commission de Magnétisme terrestre et d'Electricité atmosphérique, 4 membres seulement ont pu me proposer, de façon concrète, un candidat pour l'élection d'un nouveau président de la Commission.

Il semble donc évident qu'une telle élection se heurte à de trop grandes difficultés dans les conditions actuelles.

C'est pourquoi Monsieur Hesselberg, Président du Comité Météorologique International, a décidé d'accepter la suggestion de 3 autres membres de la Commission, proposant de charger le Chef du Secrétariat de l'Organisation Météorologique Internationale de l'administration des affaires indispensables de la Commission jusqu'à ce que cette dernière soit en mesure d'élire son nouveau président.

Les 4 membres susmentionnés qui avaient fait des propositions concrètes concernant un candidat, se sont déclarés d'accord avec la solution intérimaire, choisie par le Président du Comité.

Je vous prie donc de vouloir bien m'accorder votre confiance et votre aide dans l'accomplissement de la tâche dont j'ai été chargé.

Veuillez agréer, Monsieur et très honoré Collègue, l'assurance de ma considération très distinguée.

Le Chef du Secrétariat,
G. Swoboda

Messieurs les Membres de la
Commission de Magnétisme terrestre et d'Electricité atmosphérique

SOLAR AND MAGNETIC DATA, JANUARY TO MARCH, 1943, MOUNT WILSON OBSERVATORY

No magnetic storms were recorded in the first quarter of the year 1943. Two magnetic disturbances occurred, however, in which the horizontal component decreased by more than 100 gammas. The first began at about 19^h GMT, January 20, the second about 16^h GMT, March 29.

Three large sunspot-groups were observed: Mount Wilson No. 7550, which crossed the central meridian on February 11.7; No. 7555, on February 25.7; and No. 7559, on March 10.6. These groups, although large, were only moderately active; they were not accompanied by significant geomagnetic activity.

TABLE 1—*Solar and magnetic data*

Day	January 1943						February 1943						March 1943					
	K_2 Whole disk	K_2 Central zone	$H\alpha$ bright	$H\alpha$ dark	No. groups	Mag'c char.	K_2 Whole disk	K_2 Central zone	$H\alpha$ bright	$H\alpha$ dark	No. groups	Mag'c char.	K_2 Whole disk	K_2 Central zone	$H\alpha$ bright	$H\alpha$ dark	No. groups	Mag'c char.
1	1	0	1	1	1	0	1	0	1	2	1	0	1	0	1	1	2	0
2	1	0	1	1	1	0	1	1	1	2	2	0	1	0	1	1	2	0.5
3	0	0	1	1	1	0	1	1	1	1	2	0	...	...	...	...	...	0.5
4	0	0	1	2	1	0.5	1	1	2	1	2	0.5	...	...	...	...	...	...
5	0	0	1	1	0	0.5	1	1	2	1	1	0	...	...	...	...	...	0.5
6	1	1	1	2	1	0	1	1	1	1	3	0	1	0	1	1	1	0
7	1	1	1	2	1	0	1	1	2	1	1	0	1	0	2	1	2	0
8	1	1	1	2	1	0	...	...	...	...	...[b]	0	...	...	...	...	...	0
9	1	1	2	1	1	0	1	1	2	1	3	0	...	...	...	...	...	0
10	1	1	1	1	1	0	1	1	2[c]	1	2	0	...	...	...	...	2[a]	0
11	1	1	1	1	1	0	1	2	2[c]	1	2[a]	0.5	2	3	2	1	2	0.5
12	1	1	1	1	1	0.5	1	1	1	0	2	0	2	2	2[d]	1	2	0.5
13	1	1	1	1	2	0	1	1	2	1	2	0.5	...	...	2	1	3	0
14	1	1	1	1	1	0	1	0	2	1	2	0	2	1	2	1	2	0
15	1	0	1	1	1	0	1	0	1	2	2	0	1	1	1	2	2	0
16	1	0	1	0	0	0	1	1	1	1	1	0.5	1	1	1	2	1	0.5
17	...	...	...	...	...	0.5	1	1	1	1	2	1	...	...	...	...	...	0
18	1	1	1	1	2	0	1	1	1	1	1	...	...	...	...	...	1	0
19	1	1	2	2	2	0	...	...	1	1	2	0	...	...	...	...	2	0
20	...	...	...	...	2	1	...	...	...	...	2	0	1	1	1	2	3	0.5
21	...	...	...	...	...	0.5	...	...	...	...	...	0	...	...	...	...	3	0
22	...	...	...	...	...	0.5	...	...	...	...	...	0	...	...	...	...	2	0.5
23	...	...	...	...	...	0	...	...	...	...	...	0	2	2	2	1	3	0.5
24	...	...	...	...	...	0	...	...	...	...	...	0	2	3	2	1	3	0
25	...	...	...	...	...	0	...	...	...	...	4[h]	0.5	2	2	2	1	3	0
26	...	...	...	...	...	0	2	2	2	0	3	0.5	2	1	2	1	3	0
27	...	...	...	...	1	0	2	1	2	1	2	0.5	2	0	2	1	3	0
28	1	1	...	...	1	0	...	...	...	...	2	0	1	0	1	1	4	0
29	...	...	...	...	...	0							1	0	1	1	3	1
30	...	...	...	...	...	0							1	0	1	1	2	0.5
31	...	...	...	...	...	0							1	1	1	1	3	0.5
Mean	0.8	0.6	1.1	1.2	1.1	0.1	1.1	0.9	1.5	1.0	2.0	0.2	1.4	0.9	1.5	1.2	2.4	0.2

NOTE—For an explanation of these tables see this JOURNAL, 35, 47-49 (1930).

The character-figures of solar phenomena are estimated from the spectroheliograms which are made with a 2-inch solar image, usually in the early morning. Very bright chromospheric eruptions are reported in these notes if observed at any time during the day.

[a, b] Formation of a new group which later developed to average size or larger; (*a*) less than 30° from the center of the disk, (*b*) more than 30° from the center of the disk.

[c, d] Very bright chromospheric eruptions; (*c*) less than 30° from the center of the disk, (*d*) more than 30° from the center of the disk.

[e, f, g, h, i, j, k, l] Passage of a large or active group across the central meridian within 5°, 10°, 15°, 20°, 25°, 30°, 35°, 40° of the center of the disk, **respectively**.

CARNEGIE INSTITUTION OF WASHINGTON

PRINCIPAL MAGNETIC STORMS

SITKA MAGNETIC OBSERVATORY

JANUARY TO MARCH, 1943

(*Latitude 57° 03′.0 N., longitude 135° 20′.1 or 9^h $01^m.3$ W. of Gr.*)

January 20-21—Commencing with an increasing bay in *D* at 21^h 05^m GMT, January 20, a moderate disturbance continued through 07^h, January 21. Ranges: *D*, 71′; *H*, 565 gammas; *Z*, 577 gammas.

February 17-18—A briefly severe disturbance became noticeable at about 18^h 50^m GMT, February 17, with gradual decreases in *D* and *H* and an increase in *Z*. Large oscillations of a period of about twenty-five minutes occurred between 21^h 37^m and 23^h 11^m; then, after gradually increasing deviations from normal, all elements experienced sharp changes between 01^h 35^m and 02^h 50^m, February 18, when a *K*-index of 8 was recorded on *D*.

HAROLD W. PINCKNEY, *Observer-in-Charge*

CHELTENHAM MAGNETIC OBSERVATORY

JANUARY TO MARCH, 1943

(*Latitude 38° 44′.0 N., longitude 76° 50′.5 or 5^h $07^m.4$ W. of Gr.*)

January 20-22—A moderate disturbance began with a small bay in each of the three elements at about 06^h GMT, January 20, and appeared to have ended by 17^h, January 21, except that there was a deep bay in *D* and *H* between 00^h and 02^h, January 22. The highest *K*-index recorded during the storm was 6, for the first three-hour period of January 21.

February 16-17—A disturbance began with a small amount of short-period activity, chiefly in *H*, at about 17^h 30^m GMT, February 16. The character of the disturbance changed at about 03^h 45^m, February 17, and thereafter for about eight hours the fluctuations in all the elements were of much longer periods and larger amplitudes. At about 12^h the first type of activity was resumed, except that now it affected all the elements to some extent. The disturbance ended at about 23^h, February 17. A *K*-index of 6 was recorded for the fourth three-hour period of February 17.

March 16—A moderate, short-lived disturbance began at 05^h 46^m GMT, March 16, and ended at about 12^h. A *K*-index of 6 was recorded for the period from 9^h to 12^h.

March 22-23—A moderate disturbance, preceded for nearly a day by minor short-period activity, suddenly became more violent at 19^h 53^m GMT, March 22, the new activity being characterized by longer periods. There was no important activity after 12^h, March 23. A *K*-index of 6, and three of 5, were recorded for the storm.

March 29-30—A moderately severe storm began sharply at 18^h 42^m GMT, March 29, and ended at about 06^h, March 30. One K-index of 7 and two of 6 were recorded.

JOHN HERSHBERGER, *Observer-in-Charge*

TUCSON MAGNETIC OBSERVATORY

JANUARY TO MARCH, 1943

(*Latitude 32° 14′.8 N., longitude 110° 50′.1 or* 7^h $23^m.3$ *W. of Gr.*)

January 4-5—A very mild storm began about 10^h GMT, January 4, and continued for approximately twenty-four hours. The principal characteristic seemed to be irregular oscillations of moderately short period of D and H. Ranges: D, 11′; H, 76 gammas.

January 17—A moderately stormy period of short duration commenced suddenly at 02^h 32^m GMT, January 17, with an increase of 21 gammas in H in the first five minutes. This was followed by gradually increasing disturbance until about 13^h, after which the intensity decreased until about 21^h when the storm was almost completely gone. Ranges: D, 11′.5; H, 106 gammas.

January 20-22—A moderate storm began without sudden commencement about 04^h GMT, January 20. A large bay in H, lasting about seven hours, began at 16^h with little or no similar disturbance in Z and D. Another bay in H, lasting only about an hour, began about 00^h 25^m, January 22. Except for the two bays in H, the storm consisted mainly of irregular variations of D and H. Conditions became relatively quiet about 24^h, January 22. Ranges: D, 14′; H, 144 gammas; Z, 31 gammas.

February 16-17—A moderate storm began without sudden commencement about 18^h GMT, February 16, and continued until about 21^h, February 17. The only outstanding characteristic of this storm was a relatively large swing to the westward in declination, beginning about 10^h 30^m, February 17, and lasting for about an hour and a quarter. Ranges: D, 20′; H, 99 gammas.

February 25-27—A moderate storm began gradually about 17^h GMT, February 25. There were no unusual characteristics except possibly a somewhat larger than normal diurnal variation of Z. The Z-trace, however, showed no great amount of activity. The storm ended about 06^h, February 27. Ranges: D, 9′.5; H, 123 gammas; Z, 53 gammas.

March 22-23—A moderate storm began about the middle of the Greenwich day March 22. The activity increased gradually, and was greatest between 00^h and 08^h GMT, March 23. The intensity then decreased slowly until the storm ended at about 14^h, March 23. Ranges: D, 13′; H, 101 gammas; Z, 36 gammas.

March 29-April 1—A moderately severe storm began with an increase of about 15 gammas in H at about 10^h 36^m GMT, March 29. The rise in H was not, however, typical of a sudden commencement of a magnetic storm for it followed by about fifteen minutes a very slow 10-gamma decrease in H which gave the trace the appearance of a very small bay. At 18^h 40^m, after some minor activity, there was a sharp decrease of 14 gammas in H, followed by a sharp increase of 31 gammas at 18^h 42^m.

During the next hour and a half H decreased to about 100 gammas below its normal value and remained very low for some ten hours. The principal activity ended about 08^h, March 30, although both D and H continued to show some long-period disturbance until about 06^h, April 1. Ranges: D, 15′; H, 172 gammas; Z, 48 gammas.

J. H. Nelson, *Observer-in-Charge*

Apia Observatory

January to March, 1943

(*Latitude 13° 48′.4 S., longitude 171° 46′.5 or $11^h\ 27^m.1$ W. of Gr.*)

January 4-5—At 10^h GMT, January 4, an emergent disturbance commenced and lasted until 17^h. The trace remained slightly disturbed until 10^h, January 5.

January 16-17—A sudden commencement was recorded at $02^h\ 30^m$ GMT, January 16, with an increase in H of 19 gammas. The traces remained slightly disturbed until about 11^h, January 17.

January 20-21—The records showed slight disturbance after 11^h GMT, January 20, and a large bay was recorded between 17^h and 23^h with a minimum at 20^h. Slight disturbance continued through January 21.

February 11—A sudden increase of 13 gammas in H at $02^h\ 31^m$ GMT, February 10, marked the commencement of slight activity which lasted for seven hours.

February 13—Slight activity began with a sudden increase of 13 gammas in H at $01^h\ 18^m$ GMT, February 13. There was a further irregular increase to a maximum at $02^h\ 16^m$. The slight activity ceased at 16^h.

February 16-17—Emergent slight activity commenced about 18^h GMT, February 16, and increased moderate activity on February 17. There were a few well-defined bays and an unusual maximum in H occurred at $11^h\ 24^m$, February 17.

March 1—There was a very rapid increase of 12 gammas in H on March 1, but the trace was practically undisturbed thereafter.

March 19-20—A small sudden increase of 10 gammas in H at $20^h\ 22^m$ GMT, March 19, was followed by slight activity on March 20.

March 29-30—H increased 9 gammas suddenly at $18^h\ 37^m$ GMT, March 29, and then decreased fairly rapidly to a minimum at $21^h\ 45^m$. The range was 140 gammas. The trace gradually returned to normal on March 30.

H. Bruce Sapsford, *Acting Director*

Huancayo Magnetic Observatory

January to March, 1943

(*Latitude 12° 02′.7 S., longitude 75° 20′.4 or $5^h\ 01^m.4$ W. of Gr.*)

January 4—Beginning at about 11^h GMT, January 4, there was a short, sharp magnetic disturbance during the daylight hours which was characterized by rapid small changes in H superimposed on several narrow peaks and bays. The range was only 150 gammas during the

eight hours of the disturbance and the maximum K-index was 6. D and Z were also somewhat agitated during the active period of the storm.

January 17—A sudden commencement of 39 gammas in five minutes in the H trace was the beginning of a short and rather mild magnetic disturbance at $02^h\ 32^m$ GMT, January 17. By 20^h the activity, which was at its maximum between 12^h and 19^h, had largely ceased. There was one deep bay in H with its maximum at $13^h\ 24^m$ and several smaller peaks and bays and a total range in H of 220 gammas. D and Z were only slightly affected even during the height of the disturbance.

During the month of February there was mild activity several times, though there were no disturbances recorded which merited description.

March 29—A small disturbance at 15^h GMT, March 29, began with mild movements in H. At $18^h\ 38^m$, it was followed with a rapid increase in H of 116 gammas in six minutes. This was succeeded by an almost steady decrease with only very minor oscillations of over 190 gammas in about three hours. Then except for extremely low values of H, which were recorded during the following few days, the disturbance practically ceased. Neither D nor Z showed any serious effect of the disturbance.

Paul G. Ledig, *Oberver-in-Charge*

Magnetic Observatory, Hermanus

January to March, 1943

(*Latitude 34° 25′.2 S., longitude 19° 13′.5 or $1^h\ 16^m.9$ E. of Gr.*)

January 1-5—There was a small sudden-commencement disturbance at $15^h\ 30^m$ GMT, January 1. At the beginning of the disturbances, which continued until 21^h, January 5, the ranges were very small, but after $08^h\ 30^m$, January 4, the magnetic activity increased. The greatest K-index was 5 for the periods 12^h to 15^h and 18^h to 21^h, January 4, and 09^h to 15^h and 18^h to 21^h, January 5. There were micropulsations on all traces from $01^h\ 45^m$ to $02^h\ 00^m$, January 3.

January 8-16—There were micropulsations on all traces from $22^h\ 40^m$ to $22^h\ 55^m$ GMT, January 8, from $20^h\ 03^m$ to $21^h\ 17^m$, January 14, at irregular intervals from $18^h\ 25^m$ to $21^h\ 10^m$, January 15, from $14^h\ 07^m$ to $14^h\ 40^m$, $17^h\ 35^m$ to $17^h\ 55^m$, and $23^h\ 30^m$ to $23^h\ 52^m$, January 16.

January 17-18—A sudden-commencement storm began at $02^h\ 30^m$ GMT, January 17. H increased 32 gammas in five minutes. The storm continued until 01^h, January 18. The maximum K-index was 4 for each of the three-hour periods during 09^h to 18^h, January 17. There were micropulsations on all traces from $18^h\ 00^m$ to $18^h\ 15^m$, January 18.

January 20-23—A gradual-commencement storm began at about 09^h GMT, January 20, and continued until 03^h, January 23. The K-index was 5 for each of the three-hour periods during 15^h to 21^h, January 20, and 00^h to 03^h, January 22. For the periods 12^h to 15^h and 21^h to 24^h, January 20, and for each of the three-hour periods during 09^h to 15^h, January 22, the K-index was 4.

January 24-30—There were micropulsations on all traces from $21^h\ 21^m$ to $21^h\ 34^m$ GMT, January 24, from $19^h\ 45^m$ to $20^h\ 15^m$, January 25, from $01^h\ 40^m$ to $02^h\ 10^m$, January 26, and from $22^h\ 05^m$ to $22^h\ 12^m$, January 30.

February 1—There were micropulsations on all traces from $22^h 12^m$ to $22^h 18^m$ and from $22^h 27^m$ to $23^h 02^m$ GMT, February 1.

February 6—There were bays of K-index 3 at 01^h GMT, February 6.

February 9—There were micropulsations from $18^h 34^m$ to $18^h 41^m$ and from $19^h 25^m$ to $19^h 55^m$ GMT, February 9.

February 10-13—There was a sudden-commencement disturbance at $09^h 45^m$ GMT, February 10, followed by another at $02^h 30^m$, February 11, giving a time-interval of 16.8 hours. There were micropulsations from $12^h 20^m$ to $12^h 29^m$, February 10, from $20^h 10^m$ to $20^h 40^m$, February 11, and from $10^h 40^m$ to $10^h 46^m$, February 12. There were eight groups of micropulsations in the period $19^h 15^m$, February 12, to $00^h 10^m$, February 13. A small sudden-commencement storm, which began at $01^h 20^m$, February 13, continued for about twenty-four hours. The greatest K-index was 4 for the period 00^h to 03^h, February 13.

February 16-17—A gradual-commencement disturbance began at about 18^h GMT, February 16, and continued until about 23^h, February 17. The maximum K-index was 5 for the period 09^h to 12^h, February 17. Bays of K-index 4 were formed on all traces at 21^h, February 17.

February 18—There were micropulsations on all traces from $20^h 00^m$ to $20^h 20^m$ and $21^h 55^m$ to $23^h 15^m$ GMT, February 18; also from $21^h 15^m$ to $21^h 30^m$, February 24.

February 25-27—There were gradual-commencement disturbances from about 18^h GMT, February 25, to about 06^h, February 27. The maximum K-index was 5 for the period 00^h to 03^h, February 26.

March 1-2—Although there were sharply defined changes of magnetic values at $05^h 44^m$ GMT, March 1 (H increased 16 gammas in fourteen minutes), the magnetograms remained smooth at the changed values until $11^h 30^m$, March 1, when they became disturbed. After a few hours the magnetograms again became smooth until $01^h 45^m$, March 2. The disturbances which started then continued for about nine hours. The time-intervals were six hours and fourteen hours or twenty hours from the first to the last phase.

March 3-6—A small sudden-commencement disturbance began at $06^h 16^m$ GMT, March 3, and continued until 01^h, March 6. There seemed to be a second phase of the storm beginning at $07^h 35^m$, March 5, after a time-interval of 25.3 hours. At 21^h, March 4, bays of K-index 5 developed on all traces.

March 9-10—There were micropulsations on all traces from $21^h 20^m$ to $22^h 05^m$ GMT, March 9, from $20^h 44^m$ to $21^h 10^m$, and from $22^h 43^m$ to $23^h 10^m$, March 10.

March 11-13—Gradual-commencement disturbances began at 16^h GMT, March 11, and continued until 01^h, March 13. The greatest K-index was 5 in the period 18^h to 21^h, March 12.

March 14-15—There were micropulsations from $22^h 10^m$ to $22^h 30^m$ GMT, March 14, from 00^h to $01^h 40^m$, from $02^h 40^m$ to $02^h 50^m$, and from $03^h 35^m$ to $03^h 45^m$, March 15.

March 15-17—Small disturbances which began about $22^h 30^m$ GMT, March 15, ended at 01^h, March 17, with bays of K-index 4. The greatest K-index was 5 for the period 09^h to 12^h, March 16.

March 18-19—The first indication of approaching disturbances was a sharp change of D with smaller variations of H and Z at $06^h\ 21^m$ GMT, March 18. The traces remained smooth until $05^h\ 15^m$, March 19, except for small variations at $00^h\ 10^m$, March 19. From $05^h\ 15^m$, March 19, the disturbances continued until 23^h, March 20, with bays of K-index 4 from 17^h to 19^h, March 20. The time-intervals between these stages were 17.8 and 5.1 hours.

March 21-24—There were disturbances from 20^h GMT, March 21, to 09^h, March 24. The largest K-index was 4 for each of the three-hour periods during 15^h to 24^h, March 22.

March 26—There were micropulsations from $23^h\ 30^m$ to $23^h\ 40^m$ GMT, March 26.

March 28-31—Disturbances, which began at $19^h\ 45^m$ GMT, March 28, were very small until at $18^h\ 37^m$, March 29, there were rapid changes of K-index 7 on all elements. The disturbances continued until about 24^h, March 31, ending with bays of K-index 4. The formation of bays about the period 18^h to 24^h seems to be quite common.

A. OGG, *Magnetic-Survey Adviser*

LIST OF RECENT PUBLICATIONS

By H. D. Harradon

A—Terrestrial and Cosmical Magnetism

Chapman, S. Archaeologica geomagnetica. Terr. Mag., **48**, No. 1, 1-2 (1943).

Fleming, J. A. Terrestrial magnetism and electricity. American Year Book for 1942, 730-735 (1943). [New York, Thomas Nelson and Sons.]

Harradon, H. D. Some early contributions to the history of geomagnetism—I. The letter of Peter Peregrinus de Maricourt to Sygerus de Foucaucourt, soldier, concerning the magnet. Terr. Mag., **48**, No. 1, 3-17 (1943).

Jenny, W. P. Micromagnetics. A new quantitative geophysical method. Oil Weekly, 4 pp. (Feb. 8, 1943).

Johnston, H. F. American magnetic character-figure, C_A, three-hour-range indices, K, and mean K-indices, K_A, for October to December, 1942, and summary for year 1942. Terr. Mag., **48**, No. 1, 19-27 (1943).

McNish, A. G. Fossil magnetism. Sci. Amer., **168**, No. 4, 166-167 (1943).

Missouri Geological Survey and Water Resources. Magnetic map of Missouri showing anomalies of vertical intensity. Scale 1:500,000. 104 by 118 cm (1943). [This map was compiled from detailed magnetometer surveys in which observations were taken at one-mile intervals (usually section-corners) and from surveys in which observations were taken at intervals of two miles along highways and improved county roads. In the St. Francis Mountain Area of Iron, Madison, and St. Francis counties, where outcrops of granite and rhyolite porphyry occur, there are but few roads traversing most of the higher igneous peaks and ridges. Anomaly-values therefore were not obtained in such areas except in accessible localities. A maximum anomaly of 32,765 gammas was observed over an iron-ore deposit at Iron Mountain, St. Francis County.]

Gravimetric map of Missouri. Scale 1:500,000. 104 by 118 cm (1943). [This map was compiled from gravimeter surveys in which observations were taken as indicated along the main highways. The gravimeter used was one loaned to the American Geophysical Union by the Humble Oil and Refining Company for scientific work and made available to the Missouri Geological Survey for these investigations. Observations were made by G. P. Woollard, F. C. Farnham, Dan R. Stewart, and Kenneth Aid.]

N(ewton), H. W. Magnetic storms and solar activity 1941. Observatory, **64**, No. 807, 240-241 (1942).

Newton, H. W. A solar eruption and the magnetic storm of 1942 March 1-2. Observatory, **64**, No. 808, 260-264 (1942).

Principal Magnetic Storms. Principal magnetic storms, October to December, 1942. Terr. Mag., **48**, No. 1, 73-76 (1943).

San Fernando. Anales del Instituto y Observatorio de Marina publicados de orden de la Superioridad. Sección I. Observaciones meterológicas, magnéticas y sísmicas correspondientes al año 1941. San Fernando, iii+82 (1942). 34 cm.

Scott, W. E. The mutual consistency of successive monthly means of declination, Huancayo Magnetic Observatory. Terr. Mag., **48**, No. 1, 45-48 (1943).

Sucksdorff, E. Die erdmagnetische Aktivität in Sodankylä in den Jahren 1914-1934. Kuopio, Veröff. Geophysik. Obs., Finn. Akad. Wiss., No. 25, 68 pp., 21 figs., 41 pls. (1942). 32 cm.

WASSERFALL, K. F. Magnetic activity at Dombås based on absolute storminess for the horizontal component. Terr. Mag., **48**, No. 1, 29-39 (1943).

Vector-diagrams of annual variation of magnetic activity in declination and horizontal intensity, Oslo, 1843-1886. Terr. Mag., **48**, No. 1, 41-43 (1943).

B—Terrestrial and Cosmical Electricity

BOSS, L. J. The aurora of February 25, 1943. Pop. Astr., **51**, No. 4, 230-231 (1943).

COCCONI, G., UND V. TONGIORGI. Ueber die Lebensdauer des Mesotrons. Mit einer Bemerkung von J. Julifs. Naturwiss., **31**, Heft 9/10, 108-110 (1943).

DUPERIER, A. An exceptional increase of cosmic rays? Nature, **151**, 308-309 (Mar. 13, 1943).

EVJEN, H. M. Utility of the electric methods in geophysical exploration. Geophysics, **8**, No. 2, 146-156 (1943).

FORREST, J. S. Location of thunderstorms by radio methods. Nature, **151**, 285-286 (March 6, 1943). [Abstract of a paper read before the Royal Meteorological Society, November 18, 1942.]

GOLDE, R. H. Magnitudes of lightning currents. Nature, **151**, 421 (April 10, 1943).

HAZEN, W. E. Cosmic-ray stars at 10,000 feet. Phys. Rev., **63**, Nos. 5 and 6, 213-214 (1943).

KATZ, L., R. V. ADAMS, JR., AND W. E. DEEDS. Preliminary energy distribution curve of cosmic rays. Abstract, Phys. Rev., **63**, Nos. 3 and 4, 140 (1943).

MILLIKAN, R. A., H. V. NEHER, AND W. H. PICKERING. The origin of cosmic rays. Abstract, Phys. Rev., **63**, Nos. 3 and 4, 140 (1943).

Further tests of the atom-annihilation hypothesis as to the origin of the cosmic rays. Phys. Rev., **63**, Nos. 7 and 8, 234-245 (1943).

SWANN, W. F. G. The nature of the primary particles responsible for cosmic-ray phenomena. Phys. Rev., **63**, Nos. 5 and 6, 210-211 (1943).

WAIT, G. R. Effect of smoke on the atmospheric-electric elements at the Watheroo Magnetic Observatory. Terr. Mag., **48**, No. 1, 49-63 (1943).

WILSON, V. C., AND D. J. HUGHES. Cloud-chamber and counter studies of cosmic rays underground. Phys. Rev., **63**, Nos. 5 and 6, 161-171 (1943).

WOLF, F. Das Gewitter und seine Entladungsformen. I. Teil. Gewitterentstehung und Linienblitze. Naturwiss., **31**, Heft 7/8, 73-86 (1943).

C—Miscellaneous

APPLETON, E. V. A simple method of demonstrating the circular polarization of ionospherically reflected radio waves. Nature, **151**, 251 (Feb. 27, 1943).

BRUNNER, W. Provisional sunspot-numbers for October to December, 1942, and January, 1943. Terr. Mag., **48**, No. 1, 28 (1943).

FARRELL, M. W. The *Carnegie's* bronze hook. The Rudder, **59**, No. 5, 9-11 (1943).

HANSON, E. P. The polar route to victory. Harper's Mag., **185**, No. 1110, 639-641 (1942).

HARRADON, H. D. List of recent publications. Terr. Mag., **48**, No. 1, 73-76 (1943).

HAZEN, W. E. The specific primary ionization of cosmic rays in helium. Phys. Rev., **63**, Nos. 3 and 4, 107-110 (1943).

KAPLAN, H. G. On the mechanism of thunderstorm downdrafts. Bull. Amer. Met. Soc., **24**, No. 2, 54-59 (1943).

LYNCH, W. A. The interior of the Earth viewed in relation to earthquake causes. IV. Measurements of terrestrial magnetism tell us little about earthquakes but may tell us much about the interior of the Earth. J. Applied Phys., **14**, No. 3, 127-130 (1943).

MOUNT WILSON OBSERVATORY. Summary of Mount Wilson magnetic observations of sunspots for January and February, 1943. Pub. Astr. Soc. Pacific, **55**, 42-44, 112-113 (1943).

MULDERS, E. S. Sunspot activity during 1942. Pub. Astr. Soc. Pacific, **55**, No. 322, 21-23 (1943).

NICHOLSON, S. B., AND E. S. MULDERS. Solar and magnetic data, October to December, 1942, Mount Wilson Observatory. Terr. Mag., **48**, No. 1, 17-18 (1943).

OSGOOD, T. H. Physics. American Year Book for 1942, 743-748 (1943). [New York, Thomas Nelson and Sons.]. [Contains section on cosmic rays.]

SERBER, R., AND S. M. DANCOFF. Strong coupling mesotron theory of nuclear forces. Phys. Rev., **63**, Nos. 5 and 6, 143-161 (1943).

SIMPSON, G. C. Dr. D. la Cour (Obituary). Q. J. R. Met. Soc., **68**, No. 297, 302-304 (1942).

RYDBECK, O. E. H. Further notes on the electron density distribution of the upper ionosphere. Phil. Mag., **34**, No. 229, 130-139 (1943).

WELLS, H. W. Effects of solar activity on the ionosphere and radio communications. Proc. Inst. Radio Eng., **31**, 147-157 (1943).

NOTICE

Some of the early numbers of the Journal *Terrestrial Magnetism and Atmospheric Electricity*, in response to numerous demands, have been reprinted. A few complete unbound sets of Volumes I to XLVII, therefore, can now be supplied at $147.50 each, postpaid.

Unbound volumes can be furnished at the following postpaid prices each: I to III, $4.00; IV to XXV, $3.00; XXVI to XLVII, $3.50.

Single numbers, when possible to furnish without breaking a set, can be supplied at the following postpaid prices each: I to III, $1.50; IV to XLVII, $1.00.

Orders should be sent to the Johns Hopkins Press, Baltimore 18, *Maryland.*